Engineering News

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NEW YORK, JUNE 5, 1913

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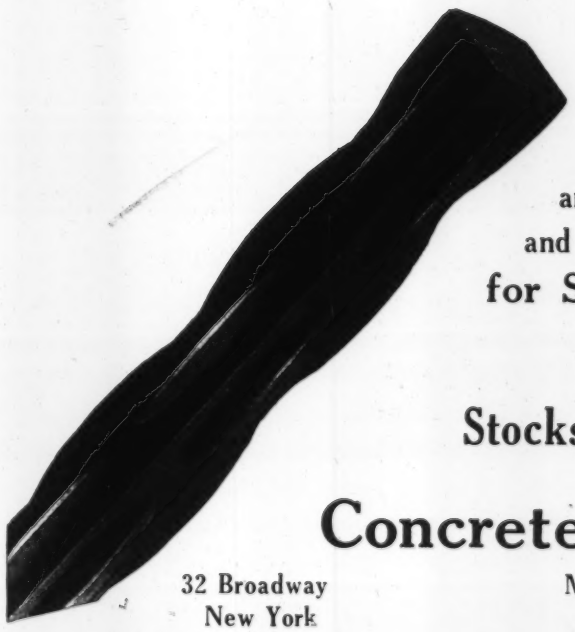

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JUN 7 1913
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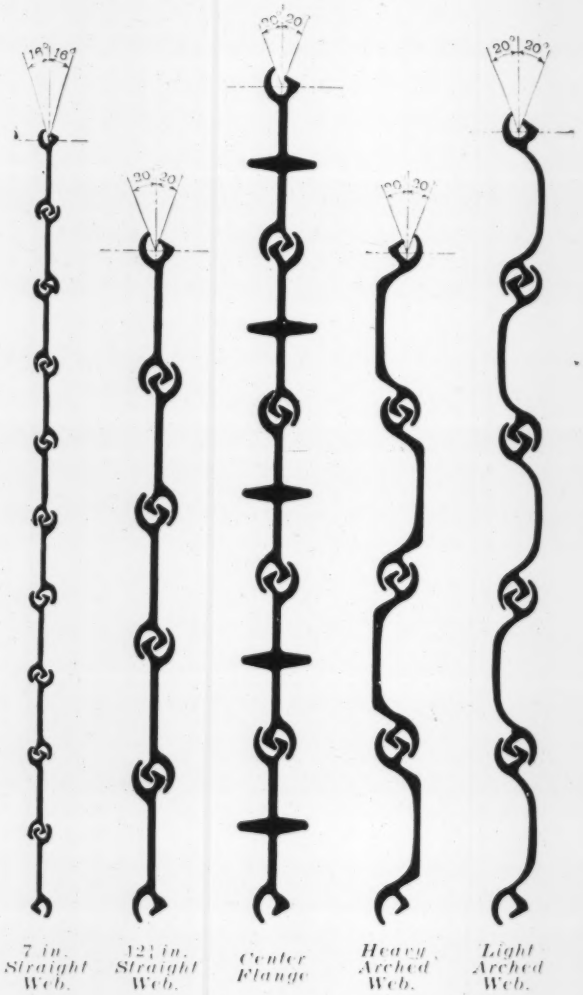
Together these sections offer at least one type and size to economically meet any sheet pile construction problem. Read over the following descriptions and tell us the types that interest you so that we can send descriptive literature.



7 in. Straight Web. *12½ in. Straight Web.* *Center Flange* *Heavy Arched Web.* *Light Arched Web.*

Straight-Web Type.—This type is suitable for general work and more especially for constructions requiring high tensional and compressive resistance of the pile, as in self-contained cofferdams made up of square, circular or rectangular filled pockets. The smaller size is especially adapted to sewer and trench work and is a great improvement over wooden sheeting for this purpose.

Center-Flange Type.—This type is designed for constructions requiring high tensional and compressive strength in connection with a fairly high transverse strength. The center flange as rolled on this section, acts as a stiffener to the web, increases the modulus of the section and furnishes means for attaching transverse ties, braces, etc., needed in special work, and tie rods in permanent protected constructions.

Arched-Web Type. This type is preferable where transverse strength of the pile as represented by the section modulus is of primary importance, as in braced or tied constructions. The high modulus of the single section per inch or width, gives a high moment of resistance per inch of width, to sustain the maximum bending moment produced by the load, which latter increases directly as the width of the pile where the pile is used as a simple, continuous or cantilever beam, retaining earth, water and other non-solid materials. A wall of this piling, however, is very thin in proportion to its transverse strength, having no greater thickness over all, at the center of the arch (the middle of the web), than the overall thickness of the interlocked joints.

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Engineering News

CHARLES WHITING BAKER, *Editor*

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Describes design developed by the Strobel Steel Construction Co.; principle consists in suspending lift span from pivoted and counterweighted lifting trusses which move on trunnions supported by towers at the end of the span; towers have racks engaging in operating pinions on the lift span. 1000 w. 3 ill. ENGINEERING NEWS, June 5, 1913.

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CIRCULATION OF THIS NUMBER OF ENGINEERING NEWS 20,000

None sent free regularly, no returns from news companies, no back numbers

WHAT THE BUYER NEEDS TO KNOW

Number Twenty-Three

We told you how by discovering a way to show a new use for an appliance, the benefit of advertising was more that doubled for the man for whom all advertising is primarily written—the reader.

This week we will show how advertising not only fulfills this office, but also serves as a safeguard against a dishonest article as well as against advertising an article for which the reader has no use.

Speaking broadly, there are two classes of products manufactured today—the product which should be advertised, and the one which should not be. Of the first class we will say more in the future.

In the latter class may be included all products which are of a fraudulent nature such as the fake patent medicines of a few years ago, lottery, bonanza mining stock, and so on.

It is through the careful investigation of the modern advertising man in seeking to find the best uses for a product that these frauds may be discovered.

A short time ago we had occasion to investigate a tool. This tool was apparently made of excellent material, and was in every way, to all intents and purposes, exactly the sort of machine that the average machine shop would need. But upon getting to the bottom of the proposition, we found in a number of cases, where these tools had been previously installed, that they had fallen down after a very short period of work. There was some flaw in the construction which could not stand the strain put upon it. This was thought to be a natural weakness until we talked to the manufacturer who refused to recognize it as a weakness and insisted upon going ahead and advertising his product in another of our papers, the American Machinist, without remedying the fault. This, of course, we refused to do.

By so doing, the reader was not only protected but the manufacturer, recognizing his inability to sell such a product, improved it and is now manufacturing the same tool with the fault eliminated.

Advertising is to the consumer what a guarantee-bonding company is to the real estate purchaser. No fault, no evil can long remain undiscovered under the white light of publicity.

Manufacturers have come to recognize this beyond the shadow of doubt—they realize that should their product not "come up to scratch," it will not long endure.

A certain large firm has this sign hanging in a conspicuous place in their reception room, "If Washington were running our business, he could sell our product and still maintain his standard of truthfulness." And this is exactly the way that most businesses are run today. The foundation upon which most merchandising efforts are built is truthfulness and *value given for dollar spent.* The exceptions are fast being gathered to their fathers.

The day when the consumer was fleeced right and left is past. Advertising of the modern kind is responsible in a large measure for this great change in selling and manufacturing methods.

Engineering News

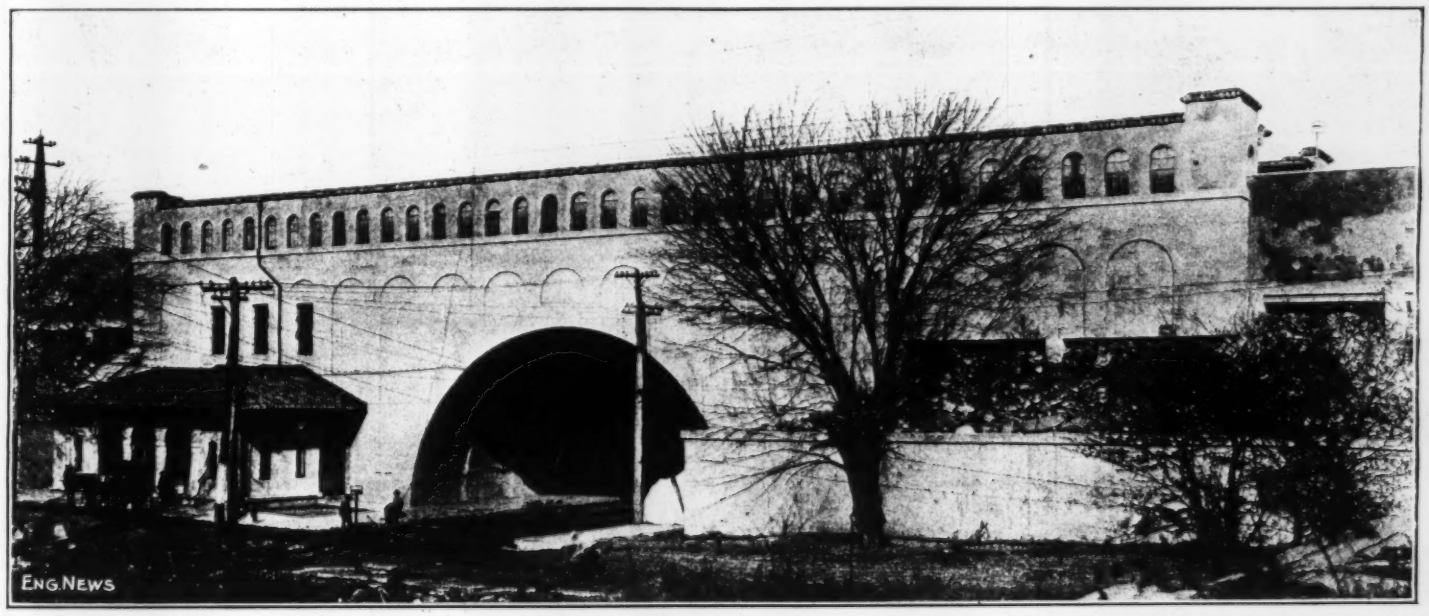
VOLUME 69 JUNE 5, 1913 NUMBER 23

The Westchester Railway Lines and Structures

SYNOPSIS.—This is the first of two articles on an electric suburban railroad built for heavy traffic. A few historical notes are given, preliminary to describing the line and station structures. An unusual collection of interesting station designs is presented. The electrical features, including catenary structures, power supply, rolling stock, and signaling system, are covered by the second article to follow.

❖

The design and construction of the New York, Westchester & Boston Ry., a heavy high-speed suburban electric line running from White Plains and New Rochelle in Westchester Co. through the Borough of the Bronx to the edge of Manhattan, and which has now been in operation for several months, presents opportunity for studies of unusual interest. While the road has been in operation on a commercial scale for several months now, yet the station structures and line equipment have not that long been fully completed, and it is only comparatively recently that the project could be truly seen in final form.



VIADUCT AND STATION OF THE NEW YORK, WESTCHESTER & BOSTON RY. AT FIFTH AVE., PELHAM, N. Y.

HISTORY

The old New York, Westchester & Boston Ry. dates back to 1872, when it was organized and started construction. It was in a receiver's hands from 1875 to 1904. The projected line is recorded as running from the Harlem River to Portchester and Mt. Vernon, with one branch from 177th St., Bronx, southeast to Throgg's Neck about four miles, and another branch from Mt. Vernon to Elmsford about eight miles. In 1904 the company obtained rights from the city of New York and the state Railroad Commission, but was held up until 1909 by the courts for a certificate of necessity and convenience. In that year it purchased the franchise for New Rochelle held by the New York & Portchester R.R., which had been organized in 1901, with a projected line from the Harlem River to Mt. Vernon and Portchester and with a branch from 177th St. southeast to Classon's Point, which is about two miles west of the Throgg's Neck end of the branch of the older Westchester road.

A new company bearing the name of the New York, Westchester & Boston Ry. was organized in 1910 as a consolidation of the two roads above noted. The new road was authorized to abandon such portions of the route of the two earlier companies not necessary for a continuous line between Harlem River and Portchester with a branch southeast to Classon's Point and Throgg's Neck and one north to White Plains.

Since the reorganization, the work has been carried forward so that one branch has reached White Plains; the Portchester branch has reached New Rochelle, and if it is continued beyond here it probably will be on the main-line right-of-way of the New Haven road.

This line is distinctively a metropolitan feeder, but it has no large or important terminal such as distinguishes most of the important suburban railroads. It must send its passengers on to other systems before they can reach their destination, the heart of the city. It should be noted, however, that this is a feature similar to

the efforts of the Pennsylvania R.R. in diverting suburban traffic from its large and expensive station at 34th St. in New York City in order to distribute these commuters along the lines of the Hudson & Manhattan Co. operating a tunnel system between New Jersey and Manhattan.

The Westchester routes bisect a territory which has relied heretofore on two now-electrified steam roads—the New York Central & Hudson River and the New York, New Haven & Hartford. (It is to be regarded as a subsidiary of the latter through ownership, although the road maintains its own indivuality of operation.) However, the new road traverses an area wherein the residents for the most part would have to walk an uncomfortably long ways to the older roads' stations.

The southern terminus of the Westchester road is the Harlem River station of the New Haven road (Harlem branch) in the Borough of the Bronx about opposite 130th St., Manhattan. Here a shuttle service connects with the Second and Third Ave. elevated lines. Morning and night, a limited number of rush-hour express trains are started from and run into this terminus to eliminate the delay and inconvenience of two transfers. A connection for transfer of passengers will be made with the Bronx terminus of the Interborough subway system, which is now only two blocks away from the Westchester station at 180th St.

The new road makes use of the tracks of the New York, New Haven & Hartford R.R. (Harlem division) for a little over three miles from the Harlem River terminal. From there to Columbus Ave. in Mt. Vernon, about 6½ miles, the Westchester has a four-track line on its own right-of-way. Just beyond the Columbus Ave. station the line splits into two double-track roads—one running two miles northeast into New Rochelle and one a little over nine miles north to White Plains.

A project is under way to further extend the service beyond White Plains, however. The Westchester Northern R.R. has been organized and has obtained rights to build northeasterly to Lewisboro on the Connecticut line and to a junction with the New Haven road in Danbury. This makes an extension of about 30½ miles. A branch line is projected from the town of Pound Ridge, in Westchester County, northerly into Putnam County

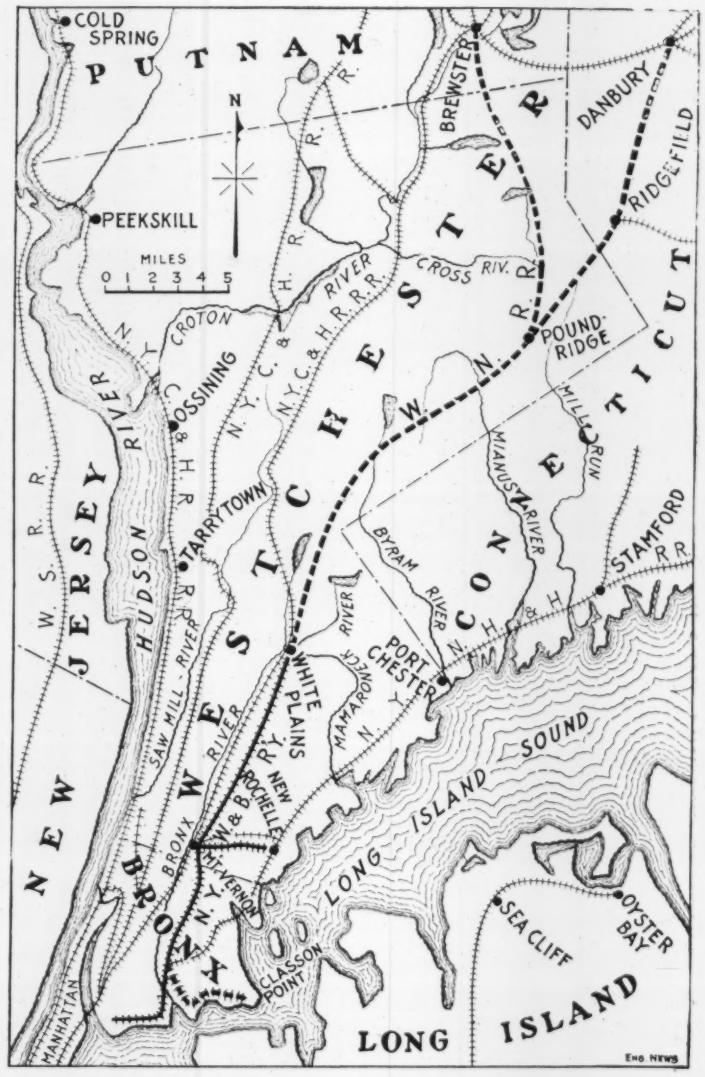


FIG. 2. MAP OF TERRITORY COVERED BY THE NEW YORK WESTCHESTER & BOSTON RY.

FIG. 3. THE WESTCHESTER STATION AT 180TH ST., BRONX, NEW YORK CITY

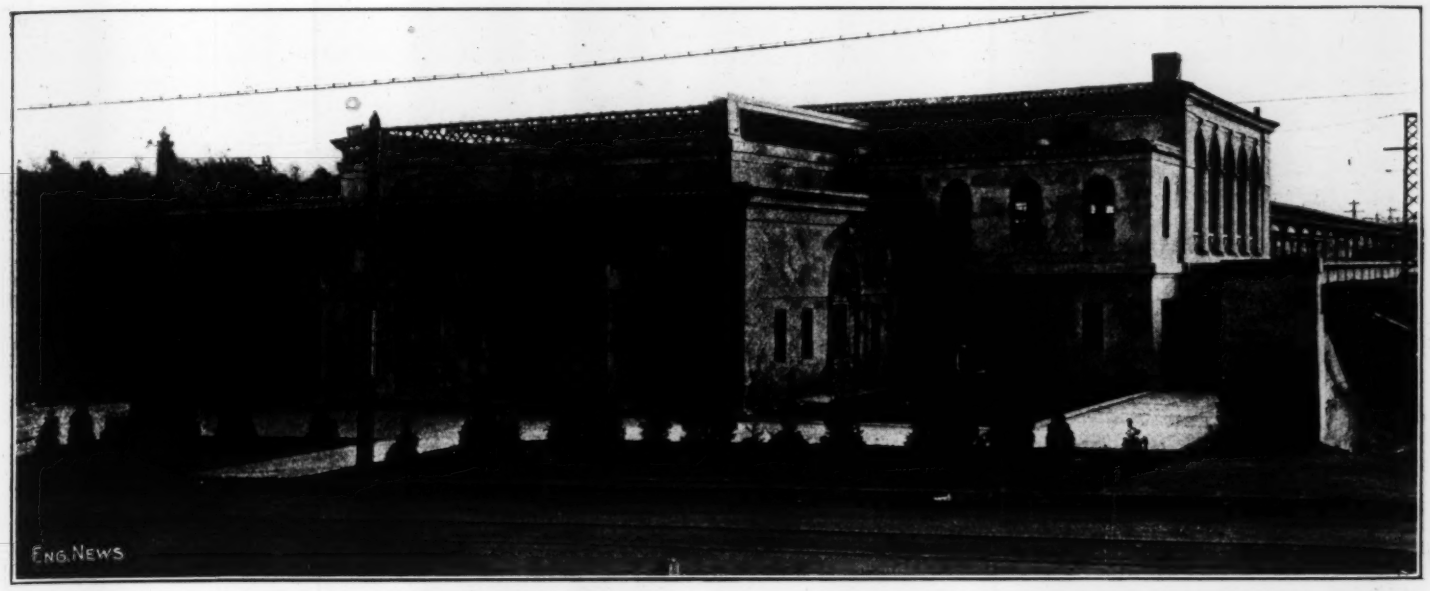


FIG. 4. THE WESTCHESTER TERMINAL IN WHITE PLAINS, N. Y.

to a junction point with the New Haven road near the New York-Connecticut state line at Brewster, about 13 miles.

SERVICE

The franchises of the New York, Westchester & Boston Ry. define the minimum number of trains and the hours of service, but in order better to attract passengers and develop new traffic those requirements have been exceeded. On the main line and on the easterly branch, stations are roughly a half mile apart, and are at twice that interval on the westerly branch. The train schedule shows 45 trains originating at White Plains on all days and 56 at New Rochelle. In general, an express from one branch always arrives at the Mt. Vernon junction station simultaneously with a local from the other branch, so that through or local passengers can transfer from one train to the other either to expedite their trip or to reach way stations as the case may be. This holds for both northbound and southbound trains, though there are a few more northbound ones per day than southbound. Sunday service is practically the same as on week days. Local trains at present are made up of only one car, and express trains are run in units of up to three cars, capacity being varied in this way rather than by a diminished schedule.

The fares are based on zone rates, there being eight 5c.-fare zones. Tickets are punched at a turnstile in front of the ticket office in each station as the passenger enters the train concourse or what corresponds in smaller stations; the punched tickets are deposited by the passenger before leaving the destination station. This arrangement removes all ticket collectors from the trains. The fare while being 5c. in one zone or between two, de-

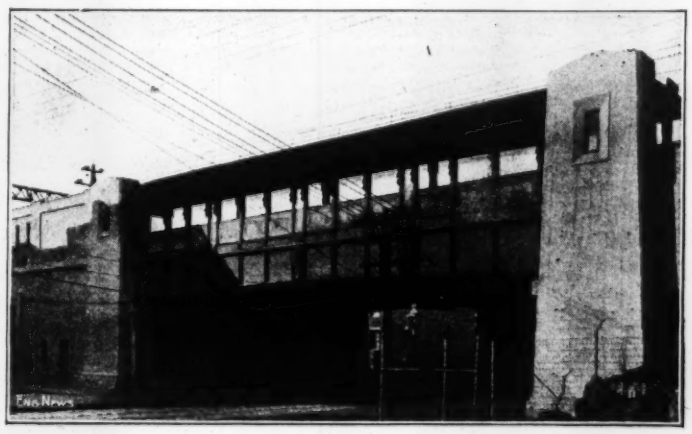
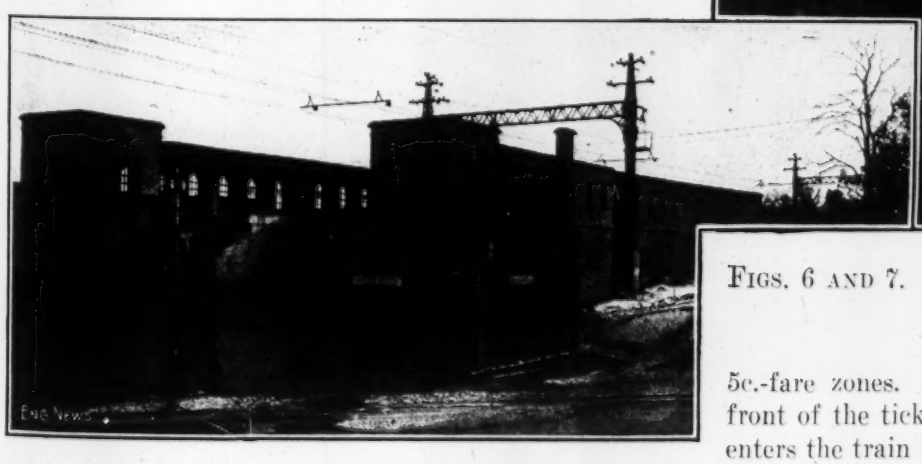
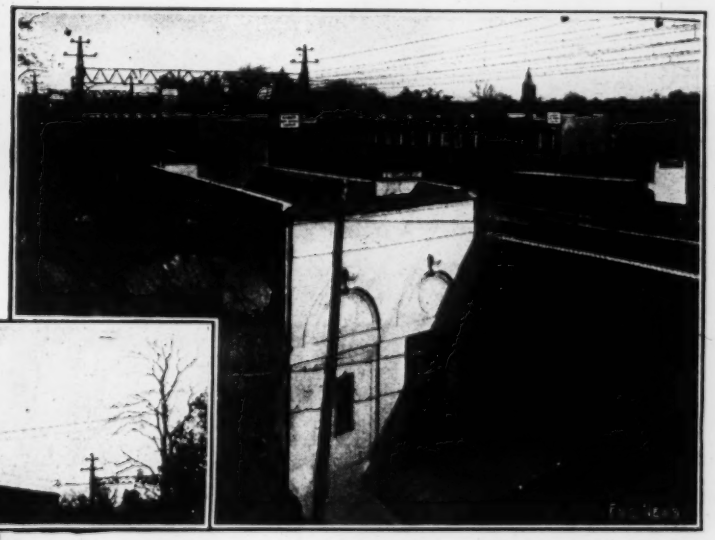


FIG. 5. STREET VIADUCT OF THE WESTCHESTER ROAD AT NEW ROCHELLE (NORTH AVE.) STATION





FIGS. 6 AND 7. WESTCHESTER STATIONS AT DEPRESSED-HIGHWAY CROSSINGS

FIG. 8. STATION AT AN ELEVATED-HIGHWAY CROSSING

creases for long rides, for instance, being 25c. for the trip between White Plains and the Harlem River terminal. Commutation rates are also in force.

ROADBED

The designers of the new line could work without having to contend with steam-road traffic structures, grades, or alignments, so that this road is a pure type of electric, high-speed, high-tension, combined trunk and local line of large passenger capacity. The right-of-way follows, of course, the general contour of the country traversed, but minor topographical impediments have been cut through, bridged, or filled more boldly than is seen in interurban electric lines, or even in some steam roads. There are in all some seven miles of cuts varying up to 30 ft. in depth and averaging about 16 ft. The fills run up to a total length of 9 miles and vary in about the same way but with a smaller average height. Grades have been limited to 1%, except in two cases (1) the junction with the New Haven road (Harlem division) and (2) the White Plains terminal approach.

The line runs in typical subway construction for a stretch of 3940 ft. near Bronx and Pelham Parkway. Here the center columns are encased in a slab of concrete for 5 ft. above the track subgrade so as to form a derailment barrier. This casing is cut into about every 30 ft. to provide safety recesses for the track employees. The electrical equipment in spite of the high voltage has been made particularly simple and strong in this subway, as noted later.

In order to eliminate all grade crossings along the road, it has been necessary to carry a little over 10% of the line on 45 odd bridges and three viaducts, and to carry 22 highways over the track. The longest of the two viaducts is 2100 ft. and is at the 180th St. station in the Borough of the Bronx, and here the viaduct and station have been combined structurally and architecturally. A four-track viaduct with 116-ft. girders carries the road (four tracks) over the main line of the New Haven road in Mt. Vernon, just before the junction of the eastern and western branches.

The rails are of standard-section 90-lb. bessemer and are laid on creosoted pine ties with tie plates at curves.

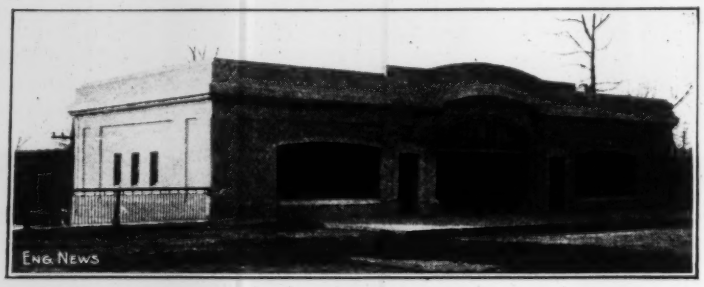


FIG. 9. A REINFORCED-CONCRETE STATION WITH SPACE FOR STORES

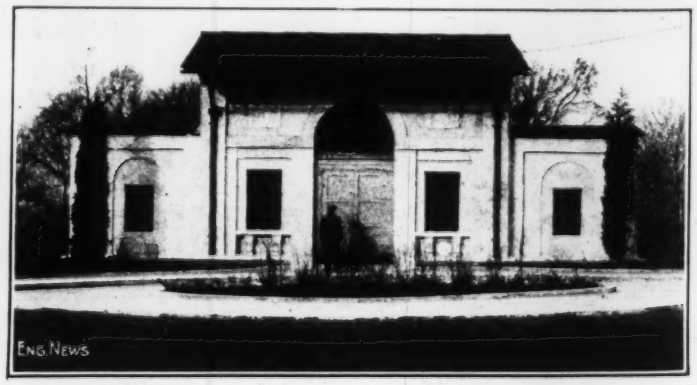


FIG. 10. A SMALL-STATION ENTRANCE

bridges and stations; common spikes are used elsewhere. The ballast is crushed trap rock. The right-of-way is fenced in throughout, posts and fencing all double galvanized.

Stations

In designing the New York, Westchester & Boston Railway Stations between 180th St. and White Plains, the physical conditions at the various station sites differed so radically that it was found impracticable to adopt an absolute standard plan for all stations, and special study was accordingly given to each station site, no two of which were identical. As a result, the stations have been designed not only to meet the commercial requirements, but to give the appearance of a close sympathy with the natural conditions existing at each particular location.

In order to avoid the lack of unity of design, usually found in a railway-station improvement when viewed together with the adjacent supporting railway structures such as retaining walls and bridge abutments, the latter were woven into and made a part of the general station design, throughout the whole Westchester project, thus securing a simple, dignified appearance of buildings and settings all along the road. Notable examples are

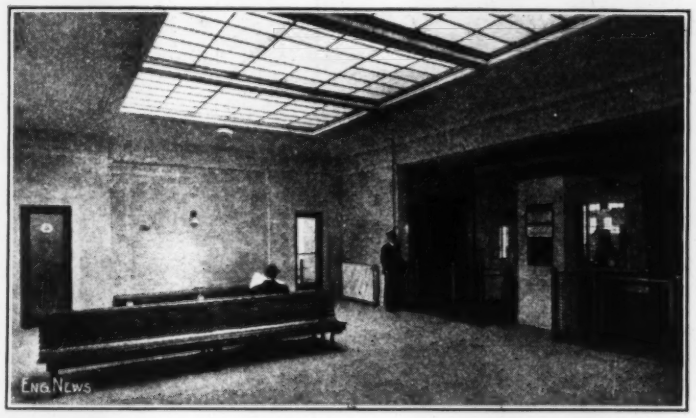


Fig. 11. Interior of a Station on the New York, Westchester & Boston Ry.

seen in the concrete arch at Fifth Ave. and Third St., Pelham, and North Ave. bridge, New Rochelle (Figs. 1 and 5). The stations at East Lincoln Ave., and Kingsbridge Ave., Mt. Vernon (Figs. 6 and 7), also will show the advantages of this treatment.

In the planning of the stations proper, the chief consideration was given to the simplicity and directness of the layout with a view to the handling of passengers with the least inconvenience and at the lowest operating and maintenance cost. Wherever possible, surplus space was devoted to rental area, such as for stores, news stands, restaurants and similar purposes. The general offices of the road are accommodated at the 180th St. station (Fig. 3).

From the waiting-rooms, direct, safe and sheltered access is provided to each passenger platform by means of overhead bridges or by tunnels under the tracks, accordingly as the track is depressed or elevated. A system of separate exits has been worked out, so that direct access may be gained to the streets for passengers leaving the stations without in any way conflicting with the incoming traffic. Another feature is the sheltered platforms, which are equipped with ample and convenient seating capacity, in order that the passengers may await their trains at the platform level, as well as in the station buildings proper.

The type of the architecture is that of the Italian Renaissance, and the general exterior color scheme adopted consists of marble stucco applied to the walls. The station roofs and the copings of all inclosure walls are formed with a roof tile of a soft reddish-brown shade.

In the interior design of the stations (see Fig. 11), special attention was paid to securing a sanitary construction which could be easily maintained and kept clean, woodwork being entirely eliminated with the exception of the doors and seats. Steel window sash were used throughout. The walls throughout the main rooms are formed with a grayish marble "granite," highly polished, with ample relief in its border lines of soft verde antique marble. A capping consists of a continuous marble band forming a Greek fret design, makes a most consistent and appropriate finish to the wall surface decorations. In all the toilet rooms a new style of sanitary facing composed of opal-glass brick with rounded corners and coves at the floor line, is used. All hardware and metal finish is simple in design and of solid cast bronze.

These structures were designed by A. Fellheimer, of Stem & Fellheimer, associate architects, New York City, to whom we are indebted for the photographs and notes. Construction work of the Westchester road is under E. J. Langford, chief engineer; P. W. J. Smith is superintendent of operation and F. Zogbaum, engineer of maintenance.

❖

A Sanitary District for Northern Indiana may be created to take care of the questions of sewage disposal and the prevention of pollution of Lake Michigan in this rapidly developing territory. The Indiana legislature has passed an enabling act for the creation of such districts, based on the organization of the Sanitary District of Chicago. It is intended specially to apply to Lake County, which is adjacent to the Illinois-Indiana state line, but as yet nothing has been done towards establishing the proposed district. The conditions of water pollution by sewage within this territory were noted in our issue of Jan. 21, 1909 (p. 78).

Interstate Bridge Purchase is to be undertaken by the states of Pennsylvania and New York, if a bill of the New York Legislature is successful.

The Delaware River is spanned by 11 bridges in that portion forming the boundary between New York and Pennsylvania. Ten of them are toll bridges owned by corporations (Port Jervis, Barryville, Lackawaxen, Narrowsburg, Skinner's Falls, Cochecton, Callicoon, Kellams, Lordville and Hancock); while a bridge at Pond Eddy was acquired some years ago by the town of Lumberland.

The matter of the acquisition of these bridges has been pending before the Legislatures of the two states for several years. The first step was taken by New York in 1905, when it authorized the superintendent of public works to make an investigation of the Delaware River bridges in conjunction with a Pennsylvania commission, and to report as to conditions found. The State of Pennsylvania did not give the necessary authority to any of its officials to represent it in such matter until 1910, and it was not until that year that the joint investigation was made. In 1911, report was made to the Legislature. The pending bill, evidently a result of the report made at that time, would create an interstate bridge commission, consisting of the state engineer, the state superintendent of public works, and a third member to be appointed by the governor, this commission to act jointly with similar officials designated by the state of Pennsylvania. The joint commission is to acquire the rights, franchises and properties of the Delaware River toll bridges, either by agreement with the owners or by condemnation proceedings under the power of eminent domain. When the bridges have been acquired, they shall be free to the public. The cost of the acquisition of the structures as well as their maintenance when acquired is to be borne jointly by the two states. The bill appropriates $175,000 from the New York treasury.

The proposed arrangement is less interesting by its magnitude than by constituting a project for interstate action.

Laws of Heat Transmission*

By Irving Langmuir†

Even in the simplest case of heat transmission, the phenomena involved usually prove to be quite complicated. It is, in most cases, nearly impossible to separate completely the effects of conduction, radiation and convection, and, therefore, if quantitative results are to be obtained, it becomes necessary to make an elaborate series of corrections, to eliminate the undesired factors.

Failure to appreciate the necessity of separating each of these factors has rendered the majority of all investigations on heat transmission previous to 1880 almost valueless. A very large number of results published even today on heat conductivity and surface emissivity are thoroughly unreliable from this cause.

It is surprising to what extent the old unreliable data maintain their place in present-day handbooks and textbooks. There is probably hardly a field in which so much care is needed in selecting proper sources for information, the whole literature being full of absolutely contradictory statements.

In the present paper the writer has attempted to present in as clear a manner as possible the fundamental laws of conduction, radiation and convection of heat, and to furnish some experimental data which seems to be of value.

CONDUCTION OF HEAT

The problem of the conduction of heat through solids was the first subject of mathematical and experimental study in the development of the theory of heat. Fourier and others developed the mathematical theory long before there was any reliable experimental data by which they could test their conclusions.

Fourier considered especially the problem of the rate of heating of a body capable of conducting heat. To solve this problem, he invented special mathematical methods which are now studied under the head of Fourier's Series. Because of the extreme complexity of this subject, mathematical analysis does not promise, for the present, to be of much value to the electrical engineer. We shall, therefore, limit ourselves to the simpler problem of the steady flow of heat which prevails after sufficient time has elapsed for the temperature through the apparatus to become constant.

For this case of steady heat flow through solids, the general law may be stated

$$W = \frac{A}{l} \mathbf{k} (T - T_0) \qquad (1)$$

where

W = Watts of heat flow;
A = Area of cross-section of path of heat flow;
l = Length of heat path;
$\mathbf{k}$ = Coefficient of heat-conductivity expressed in watts per cm. per deg.;
$T - T_0$ = Difference of temperatuse causing the heat flow.

HEAT CONDUCTIVITY OF SOLIDS—The heat conductivity $\mathbf{k}$, of solid bodies varies greatly for different substances, ranging from 4.2 watts per cm. per C° for pure silver to 0.0016 for such substances as rubber. The conductivity of finely divided solids, fibrous materials, powders, etc., is very much less than that of homogeneous solids. The best heat insulators known, such as eider-down, have a conductivity as low as 0.00020 watts per cm. per C°.

In Table I the writer has collected together all of the reliable data he has, by careful search, been able to find on the conductivity of such materials as are of interest to the electrical engineer.

In this table it will be noted that the conductivities of various substances of any one type do not differ very greatly from one another; for example, the range of conductivities of organic materials used for electrical insulation is from about 0.0015 to 0.0040. The presence of air spaces in a body very much decreases the conductivity, as is seen for the extremely low conductivities of such materials as wool, cotton batting, etc. That this high thermal resistance is entirely due to the presence of gas is evident from the fact that these materials are relatively good conductors when placed in an atmosphere of hydrogen.

In the case of powdered or fibrous materials, the heat conductivity is practically independent of the true conductivity of the solid substance forming the grains or fibers encountered.

For example, finely divided metallic powders, such as zinc dust or tungsten reduced by hydrogen from finely divided oxide are extremely good heat insulators, although the material itself is a good heat conductor.

The conductivity of liquids is quite low, and is in most cases very insignificant compared with the amount of heat carried through the liquid by convection currents. The figures given above for liquids can be used only for liquids through which heat is being transmitted downward, or in the case where the liquid is held in the meshes of some fibrous material such as cloth.

TEMPERATURE COEFFICIENT OF HEAT CONDUCTIVITY—Pure metals, although they have a large temperature coefficient of electrical conductivity, have a thermal conductivity which is practically the same at all temperatures. Alloys have a conductivity which usually increases somewhat with the temperature, the temperature coefficient being never greater than about 0.1% per C°.

In the case of pure crystalline, nonmetallic substances, Eucken ("Ann. d Physik, Vol. 34, p. 185, 1911) has shown that the thermal conductivity varies approximately inversely proportional to the absolute temperature. In others words, the temperature coefficient of such substances is usually about —0.33% per C°.

The same investigator has also shown that with amorphous, nonmetallic substances, like glass, the conductivity increases slightly with increase of temperature, the temperature coefficient being about +0.15% per deg. C°. Such substances as paraffin, ebonite, etc., are found to have practically no temperature coefficient.

Tests made by C. P. Randolph have shown that for powdered or fibrous materials the temperature coefficient of heat

TABLE I. THERMAL CONDUCTIVITIES AND RESISTIVITIES OF VARIOUS MATERIALS

Materials	Temp., C°	Conductivity, watts per cm. per C°	Resistivity	References
Metals				
Pure copper	18	3.84	0.260	2
Commercial copper	18	3.50	0.285	2
Pure iron	18	0.67	1.49	2
Steel (1% C)	18	0.45	2.22	2
Cast iron	100	0.40		
Transformer steel (4% Si)	20–250°	0.32	3.12	1
Brass	20–250°	1.30	0.77	1
German silver (30% Ni)	20–250°	0.28	3.6	1
Constantin (60 Cu, 40 Ni)	18	0.29	3.5	2
Calorite (65 Ni, 15 Fe 13 Cr. 7 Mn)	20–250°	0.16	6.2	1
Mineral Substances				
Graphite		3.57	0.28	11
Marble		0.030	33	3
Slate		0.020	50	3
Glass		0.011	90	4
Quartz glass		0.015	67	10
Porcelain		0.010	100	5
Insulating Materials				
Shellac		0.0025	400	4
Para rubber		0.0016	620	3
Gutta percha		0.0020	500	3
Paraffin		0.0026	390	3
Ebonite		0.0018	550	4
Paper		0.0013	770	3
Asbestos paper		0.0025	400	3
Varnished cambric		0.0025	400	6
Rubber tape		0.0043	230	6
Fullerboard varnished		0.0014	710	7
Pure mica		0.0036	280	7
Linen tape varnished and baked		0.0015	670	7
Miscellaneous materials	Apparent density grams per cu.cm.			
Cotton batting, loose	0.21	0.0046	2200	1
Cotton batting, tightly packed	0.10	0.00030	3400	1
Pure woolen wadding, loose	0.015	0.00049	2040	1
Pure woolen wadding, packed slightly	0.054	0.00036	2800	1
Pure woolen wadding, tightly packed	0.192	0.00023	4400	1
Eider down, very loose	0.0022	0.00045	2200	1
Eider down, slightly packed	0.077	0.00025	4100	1
Eider down, tightly packed	0.11	0.00019	5200	1
Soft white pine cross grain		0.0016	640	
Liquids				
Water 25° C		0.0057	176	4
Paraffin oil		0.0014	710	8
Glycerin 25° C		0.0024	410	4
Petroleum 23° C		0.0016	630	8
Gases				
Air at 20° C		0.000249	4010	9
Air at 100° C		0.000300	3330	9

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conductivity is very large. For example, measurements of the heat conductivity of popped water glass at various temperatures up to 500° C. gave the results:

Range of temperature	Heat conductivity Watts per cm. per C°
20—100	0.00030
100—200	0.00039
200—300	0.00057
300—400	0.00076
400—500	0.00133

This material had an apparent density of 0.026 and contained air cells of about 0.5 mm. average diameter. The large temperature coefficient is caused by radiation across the walls of the air cells, which is relatively large at high temperatures but almost negligible at room temperature. Below 100° C. the temperature coefficient for powdered and fibrous materials may be taken as +0.3% for materials with a coarse structure and proportionately less for finer structure.

In the case of gases, the mobility and the coefficient of thermal expansion are so great that convection becomes very large. It was thought for a long time that gases had no true conductivity. Maxwell, however, calculated the conductivity from the kinetic theory, and predicted that it would be independent of the pressure. His results have since been thoroughly verified. To avoid convection currents, it is only necessary to reduce the pressure of the gas to a value of several centimeters. At lower pressures the heat conductivity is found to be entirely independent of the pressure down to a pressure of 1 mm. When the pressure becomes much less than this, the free path of the molecules begins to become comparable with the length of the path along which the heat is conducted. At still lower pressures, the heat conductivity becomes proportional to the pressure. It is evident that the pressure at which the change from one of these laws to the other takes place is inversely proportional to the length of the path of heat flow. In the case, therefore, where we have the space subdivided by the presence of a fibrous material, we find that the heat conductivity does not remain constant down to such low pressures as 1 mm., but may even, with very finely divided materials, decrease with decreasing pressure, from atmospheric pressure down. This subject has been very fully treated by Smoluchowski ["Anz. Akad. Wiss. Krakau" (1910) A. 129-153].

In the case of the heat conduction of gases, we find there is a large temperature coefficient of heat conductivity. It has been thoroughly proven that Sutherland's formula

$$\mathbf{k} = \frac{K c_v \sqrt{T}}{1 + \frac{C}{T}} \qquad (2)$$

very accurately represents the change in conductivity with the temperature. Here "K" is a constant, "c_v" is the specific heat of the gas at constant volume, and "C" is a constant equal to 124 for air.

In general, when "**k**" is a function of the temperature, we cannot use equation (1) to calculate the heat conduction through a given body. It can be shown, however, [Langmuir, "Phys. Rev.," Vol. 34, p. 406 (1912)], that if we substitute for the factor $\mathbf{k}\ (T - T_0)$ the integral $\int_{T_0}^{T} \mathbf{k}\ dT$ we are then able to calculate the heat conduction, no matter how much the heat conductivity may vary with the temperature. For such cases as these, the results can be calculated most easily by calculating or plotting the values of the integral $\int_{0}^{T} \mathbf{k}\ dT$. If we represent by ø the value of this integral, which we may call specific conduction, then the formula for heat conductivity becomes

$$W = \frac{A}{l}(\phi - \phi_0) \qquad (3)$$

CONDUCTION THROUGH BODIES OF VARIOUS SHAPES.

Equations (1) or (3) can be used only for the heat conduction between parallel planes. In other cases, "A" and "T" are both variables, and the proper mean values must be determined by special methods.

No matter what the shape of the body, the ratio $\frac{\text{"A"}}{l}$ has a definite value, if the surfaces of in-flow and out-flow of the heat are fixed. Let us call this quantity the "shape factor," and represent it by the letter "s." Our equation for heat conduction thus becomes

$$W = s\ (\phi - \phi_0) \qquad (4)$$

The value of the shape factor for bodies of various shapes may be of interest. The following cases are worthy of considering here:

Planes

$$s = \frac{A}{l}$$

Concentric cylinders of diameters "a" and "b."

$$s = \frac{2\pi}{\ln \frac{b}{a}} \qquad (5)$$

Concentric spheres of diameters "a" and "b."

$$s = \frac{2\pi}{\frac{1}{a} - \frac{1}{b}} \qquad (6)$$

Concrete Rectangular Prisms or Parallelopipedons. For this case the following formula applies with great accuracy to the flow of heat where the thickness of the heat-conducting material between the two surfaces is constant and where the thickness of the layer is not more than 2½ times the smallest dimension of the prism, a condition nearly always fulfilled in practice. The formula is

$$s = \frac{A}{t} + \tfrac{1}{2}\Sigma l + 1.2\,t \qquad (7)$$

Here "t" is the thickness of the layer of conducting material, "Σl" is the sum of the length of the 12 edges of the inner prism, and "A" is the total surface of the inner prism.

RADIATION OF HEAT

Dulong and Petit (1817) gave an empirical formula for heat radiation which has been used very largely by engineers almost up to the present date.

The Stephan-Boltzman law, as applied to the radiation body" is proportional to the fourth power of the absolute temperature has been shown to be derivable from the second law of thermodynamics, and has withstood the tests of very careful experimental investigation. We may, therefore, look upon this law as being one of the exact laws of nature. It must be remembered, however, that it applies only to radiation from a so called "black body"; that is, a body which absorbs all heat rays which fall on it. Such a body can only be approximately realized, and any actual body must radiate less heat than an ideal black body at the same temperature.

The Stephan-Boltzman law, as applied to the radiation from any given body, may be written

$$W = 5.7\,e\left[\left(\frac{T}{1000}\right)^4 - \left(\frac{T_o}{1000}\right)^4\right] \qquad (8)$$

Here "**W**" is the energy in watts radiated per square centimeter of surface; "T" is the temperature of the hot body, and "T_o" the temperature of the surrounding space, "e" we may call the relative emissivity of the body; it is always a number less than unity and is a characteristic property of the radiating body.

The radiation constant, 5.7, is subject to some uncertainty at present. For several years, the commonly accepted value was 5.32, which was the result obtained by Kurlbaum ("Wied. Am.," 65, 746, 1898). Recently, however (1909), Féry obtained a value 6.3. Since then many investigators have redetermined this constant. Paschen and Gerlach ("Ann. d Physik," Vol. 38, p. 30, 1912) obtained the value 5.9. Shakespeare ("Proc. Roy. Soc.," Vol. 86A, p. 180,1911) obtained 5.67. Within the next year or so the correct value of this constant will undoubtedly be determined. For the present, it would seem almost certain that the value 5.32 is too low, and that the value 5.7 must be fairly close to the true value.

The radiation of heat differs from conduction and also convection in that it is a purely surface phenomenon. The amount of heat radiated is strictly proportional to the extent of the surface, and is independent of the presence of gas adjacent to the surface. From bodies that are not black, the heat radiated from cavities in the bodies has a greater intensity than that radiated from a flat surface, for the reason that from such a cavity there is not only the heat radiated from the bottom of the cavity, but also that reflected by the bottom surface from the walls of the cavity. The above equation for radiation, therefore, applies only for heat that comes directly from a surface, and not for that which has been reflected from the surface. In general, however, this factor is not a difficult one to take into account in the consideration of heat radiation.

The most difficult question involved is the determination of the relative emissivity "e." For clean polished surfaces of metals this quantity is small, ranging from 0.02 to 0.20. For nonmetallic substances it is usually very much larger than this, ranging from about 0.3 up to about 0.9. The following table gives the values of "e" calculated by the writer from measurements made by C. P. Randolph. (A detailed description of these measurements will be published in the "Trans." of the Am. Electrochem. Soc., Vol. 23, 1913.)

TABLE II. VALUES OF HEAT EMISSIVITY

Copper, oxidized by heating to a red heat	0.74
Copper, calorized; that is, surface impregnated with Al	0.27
Silver, pure, polished	0.03
Cast iron, fresh machined surface	0.25
Cast iron, oxidized by heating to red heat	0.65
Aluminum paint on cast iron	0.47
Gold enamel on cast rion	0.39
Monel metal, polished	0.40
Monel metal, oxidized	0.45

The relative emissivities from highly polished metal surfaces can be calculated from the reflectivity of the surface for heat rays, the emissivity and reflectivity being complementary to each other. That is the emissivity is equal to "1 — r" where "r" is the reflectivity. There is a considerable amount of data in the literature on the reflectivities of metals for heat rays. However, it has been shown by Hagen and Rubens ("Ann. d. Physik," Vol. 8, p. 1, 1902) that the relative emissivity may be calculated by the formula

$$1 - r = e = 0.365 \sqrt{\frac{\theta}{\lambda}} \qquad (9)$$

where θ is equal to the specific electrical resistivity in ohms centimeter units at the temperature of the metal and λ is equal to the wave length of the radiant energy in centimeters.

Recent investigations have shown that this formula is very accurate for wave lengths exceeding 0.005 mm. in length. The average wave length of the light corresponding to any given temperature is, according to Wien's radiation law, approximately $\frac{0.29}{T}$ cm. If we substitute this in the above equation, we obtain the value

$$e = 0.68 \sqrt{\theta T} \qquad (10)$$

This equation enables us to calculate the relative emissivity for any highly polished metal up to about 500 or 600° C. However, because of surface oxidation, the emissivity will nearly always be much larger than this except with such metals as silver, platinum and gold.

Organic substances, such as oils, varnishes, resinous materials, have a very high emissivity; that is, between 0.8 and 1. Although in the visible spectrum these bodies are transparent, they are practically black bodies as regards the long heat rays that are involved in the radiation from bodies at ordinary temperature. The same is true of glass, this being practically a black body with respect to heat rays.

TEMPERATURE COEFFICIENT OF RADIATION—For small differences of temperature, equation (8) may be written

$$W = 0.0228\, e \left(\frac{T_o}{1000}\right)^3 (T - T_o) \qquad (11)$$

We thus see that the amount of radiation between two bodies having a given difference of temperature, increases in proportion to the third power of absolute temperature. This means that the temperature coefficient of radiation between two bodies differing only slightly in temperature, is + 1.0% per C°. This is at least three times greater than the temperature coefficient of heat conduction through solids or even gases.

CONVECTION OF HEAT

The transmission of heat through liquids or gases takes place principally by means of currents set up in the fluid because of differences of density produced by the unequal heating. The amount of heat carried by convection depends on the velocity of the convection currents and also on the specific heat of the fluid. The currents are produced by the differences in density between the fluid in contact with a hot body and in contact with the cold body. We may say, in a general way, that the amount of heat carried by convection will be roughly proportional to the product of specific heat, density, and expansion coefficient, and will be approximately inversely proportional to the viscosity of the fluid.

From the very nature of convection, we would hardly expect it to obey such simple laws as those of radiation. It will depend upon the shape of the hot body, the distance between the hot body and the cold body, and upon each of the factors mentioned in the paragraph above.

There have been a great many investigations made of the laws of convection of heat, especially in gases. Dulong and Petit, in 1817, derived several empirical laws which were more or less verified over rather narrow ranges of temperature by Péclet (1860). These laws are today used in many engineering handbooks as best representing the knowledge of convection of heat. Within the last 30 years, however, much more valuable work has been done, and we now know that the formulas of Dulong and Petit are only rough approximations

Lorenz ("Ann. d Physik," Vol. 13, p. 582, 1881) derived formulas for the convection of heat from vertical plane surfaces, making, however, certain rather arbitrary assumptions. He obtained the formula

$$W_c = 0.548 \sqrt[4]{\frac{c\, g\, k^3}{h\, H\, T}} \sqrt{\rho}\, (T_2 - T_1)5/4 \qquad (12)$$

where W_c = heat convection per unit surface, c = specific heat of the gas at constant pressure, k = its thermal conductivity, h = its viscosity, T = its average temperature, p = its average density, g = gravitational constant, T_2 = temperature of plane surface; T_1 = temperature of the gas at a great distance from the plane, H = height of the plane.

Putting in the data for air, at room temperature, 27° C. and standard atmospheric pressure, this equation reduces to

$$W_c = 0.000399\, H^{-\frac{1}{4}} (T_2 - T_1)5/4 \qquad (13)$$

where "W_c" is expressed in watts per sq.cm., and "H" is in cm.

This equation agrees well (within 5%) with the results calculated by the writer from the experimental results of C. P. Randolph on the convection of heat from disks of metal 7½ in. in diameter. It is very probable, from the method of derivation of this equation, that the influence of the height of the plane on convection is not as great as indicated by the term "$H^{-\frac{1}{4}}$" in the equation.

The writer ("Phys. Rev.," Vol. 34, p. 401, 1012) showed that the free convection of heat from small wires consisted essentially of conduction through a film of gas of definite thickness. It was shown experimentally that the thickness of the firm is independent of the temperature from 100° C. up to the melting point of platiaum. The thickness of this film depends on the diameter of the wire, but in such a way that it may be calculated with no other data than the diameter of the wire and the diameter which the gas film would have in the case of convection from a plane surface. To calculate the heat lost by convection from any wire, all that is required is to know the coefficient of heat conductivity of the gas and the thickness of this gas film for a plane surface, this latter being a constant quantity characteristic for a gas at any given temperature and pressure.

It was shown [Langmuir, "Proc.," Am. Inst. E. E., Vol. 31, 1011 (1912)] that the formulas derived from this film theory agreed excellently with the experimental data of Kennelly ("Trans.," A. I. E. E., Vol. 28, p. 363, 1909) on the convection of heat from small copper wires in air at various pressures and in air moving at different velocities.

In the following, the writer has attempted to give the principal laws for the convection of heat under the different conditions which influence it.

FREE CONVECTION—The film theory of convection makes it possible to calculate the convection from plane surfaces, from cylinders or wires of any diameter, and from spheres.

In the case of plane surfaces, the heat lost by convection is calculated simply by considering that there is a layer of air 4.3 mm. thick, adhering to the surface, and through which the heat has to be carried by conduction. It must, of course, be remembered, that in addition to this heat loss by convection, there is the heat lost by radiation.

This film theory fully explains the fact that for wires of very small diameter the heat lost by convection is nearly independent of the diameter. This follows from the shape factor (see equation 5) for concentric cylinders, since the logarithm of a number varies only slowly as the number increases.

The amount of convection from the surface differs only slightly whether the surface is placed vertically or horizontally. With a surface placed in the latter position, so that it is exposed to the air above it, the heat lost by convection is about 10% greater than when the surface is placed vertically. With the surface horizontal, but inverted so that it must lose its heat downward through the air, the heat lost by convection is naturally considerably less. For a 7½-in. (19 cm.) disk, placed in this position, the heat loss was actually found to be only 50% of the heat lost when the surface was placed vertically.

The amount of convection from a surface probably does not depend, to any great extent, on the nature of the surface. At least, as far as the writer knows, there is no trustworthy experimental evidence that the surface has any influence.

It is a surprising fact that between temperatures of 100° and 500° C., the convection calculated from the film theory as above outlined, gives nearly identical results with those calculated by Lorenz's formula (see equation 12). At temperatures above 500° C., both for convection from plane surfaces and from wires, the convection calculated from the film theory agrees better with the experimental facts than that calculated from Lorenz's formula. At temperatures much below 50° the two formulas begin to diverge quite widely. The film theory would indicate that the convection would fall off practically linearly as the temperature difference decreases; whereas, according to Lorenz's equation, the temperature would be proportional to the 5/4 power of the temperature difference. This would mean that for very slight differences of temperatures, for example, 5° or 10°, that Lorenz's equation would give very much lower results than would be obtained from the calculation from the film theory.

To decide which of these two theories would give the correct result for very small temperature differences, will require careful experimental investigation. Probably the bulk of the evidence at present is in favor of Lorenz's equation.

It should be pointed out that there is no theoretical reason known why the thickness of the film should remain constant, as the temperature of the wire or plane varies. This is simply an experimentally determined fact at temperatures above 100° C. It is quite possible that for very small temperature differences, the film thickness might become greater. In any case, however, the variation in the film thickness down to temperature differences as low as 30° would not be very important in most calculations of heat convection.

EFFECT OF PRESSURE ON FREE CONVECTION—The heat conductivity of gases is independent of the pressure. According to the film theory, therefore, the effect of pressure on the amount of heat convection would depend simply upon the effect of pressure on the film thickness which we will call "B." Theoretically, it would be very difficult to determine exactly what this effect would be. But it is certain that as the density of the gas decreases by the reduction of pressure, the thickness of the film "B" would increase; not necessarily inversely proportional to the pressure, however.

From Kennelly's data, the writer found that "B" varied inversely proportional to the 0.75 power of the pressure. From recent experiments with small wires in air, over a wide range of pressure, the writer finds that "B" varies nearly inversely proportional to the first power of the pressure. From small wires, however, the amount of heat convection depends only slightly upon the diameter of the film. In these experiments, therefore, it is very difficult to find accurately the law according to which the film thickness varies with the pressure. As the size of the wire decreases, the convection becomes less and less sensitive to pressure changes.

For the effect of pressure on the convection from plane surfaces, there is only very meager experimental data. Compan, in studying the convection from spheres 2 cm. in diameter, concludes that the convection varies with the 0.45 power of the pressure. According to Lorenz's equation, the amount of convection from plane surfaces would be proportional to the 0.5 power of the pressure. This would be equivalent to saying that "B" varies inversely proportional to the 0.5 power of the pressure.

To decide exactly how convection varies with pressure, we require further experimental work on plane surfaces in air at various prssures. Provisionally, it is probably safe to say that for the convection from plane surfaces or wires, the value of "B" is inversely proportional to the 0.5 power of the pressure.

EFFECT OF TEMPERATURE ON FREE CONVECTION—From experiments by the author on convection from platinum wires in air at various temperatures from —180° up to 700° C., it would appear that the film thickness for a plane surface is approximately proportional to the absolute temperature.

The temperature coefficient of heat convection for small wires will simply depend on the temperature coefficient of the heat conductivity of the air, since in this case the amount of heat convection depends so slightly on the film thickness. From Sutherland's equation (2) it may be shown that in the neighborhood of room temperature, the heat conductivity of air increases approximately proportional to the 0.76 power of the absolute temperature. This would mean that the temperature coefficient of heat conductivity at room temperature is +0.25% per C.°, and this would be the temperature coefficient of heat convection from the wire.

In other words, more energy would be required to maintain a wire at a given temperature elevation above its surroundings, the greater the temperature of the surroundings.

It is quite different with the convection of heat from plane surfaces. Here, the convection depends not only on the heat conductivity of the air, but also on the thickness of the film. Since the latter varies proportionally to the temperature, the amount of convection from plane surfaces will be proportional to

$$\frac{T^{0.76}}{T} = T^{-0.24}$$

In other words, the temperature coefficient of the heat convection will be —0.08% per C.° From plane surfaces the convection with a given temperature difference decreases slightly with increasing air temperature.

Lorenz's equation would lead to the temperature coefficient of —0.37% per C.°, for convection from plane surfaces.

FORCED CONVECTION—The effect of air currents on convection is very great, as is well known. However, the air currents that occur in an ordinary room, at some distance from the windows, have only very slight effect on the convection from wires and plane surfaces heated to several hundred degrees. By placing a few large screens around the body, very consistent results are obtained. With higher wind velocities, such as those obtained by placing an electric fan close to the body, the amount of convection, both from plane surfaces and from wires, increases about fourfold. Measurements with an anemometer showed the wind velocity in this case to be about 400 cm. per sec.

Kennelly has investigated the effect of wind velocity on convection from small wires, and has found that the amount of convection varies approximately in proportion to the square root of the velocity. For velocities from 300 to 1800 cm. per sec., he finds that the convection is proportional to the quantity

$$\sqrt{\frac{v + 25}{25}}$$

That is, the convection of any given wind velocity can be calculated from the velocity in quiet air by multiplying by the above factor.

It has been found that the film thickness, in the case of forced convection from plane surfaces, is very different from that found for small wires in wind of the same velocity. This fact renders the film theory almost useless in cases of forced convection.

The best single equation for the calculation of convection of wires is probably an equation calculated by Russell ["Phil. Mag.," 20, 591 (1901)] by the method first given by Boussinesq. This equation is

$$W = 8\sqrt{\frac{c\rho k v a}{2\pi}}(T_2 - T_1) \qquad (14)$$

where W = convection loss per unit of length from the cylinder, c = specific heat of the gas or liquid at constant pressure, ρ = density ofthe fluid, k = heat conductivity, v = velocity, a = diameter of the cylinder, $T_2 - T_1$ = difference of temperature between the cylinder and the fluid.

If, in this equation, instead of the coefficient 8 in front of the radical sign, we place 5 or 6, we find that the results agree well with Kennelly's experimental data. On the other hand, for large cylinders from 2 to 10 cm. in diameter, the formula gives good results with the coefficient between 7 and 8.

In the case of forced convection in air at room temperature, equation (14) reduces to

$$W = 0.000180\ C\sqrt{Va}\ (T_2 - T_1) \text{ watts per cm.} \qquad (15)$$

where "C" is the number that varies from 5 to 8, according to the size of the wire as described above.

From equation (14) we can calculate that with a given difference of temperature and given wind velocity, the amount of convection would vary with $\sqrt{T^{-1+0.76}}$. This would mean that forced convection under these conditions would have a temperature coefficient of —0.04% per C°; that is, with a given difference of temperature, the amount of convection would decrease slightly as the temperature of the air increases.

If the velocity of the air is produced by centrifugal force, the velocity of the air currents will probably decrease as the air temperature increases, since the density decreases and the viscosity increases. The effect of this would be to make the temperature coefficient numerically still greater.

If the convection currents are caused by flue action (for example, because of heat given to the air in long passages), this effect will be still more marked, so that the temperature coefficient will be strongly negative.

In problems on convection of heat, the flue action is often very important. For example, in studying the convection from a horizontal, plane disk, 7½ in. in diameter, we find that if we place a cylinder of asbestos paper about 10 in. in diameter and 6 in. high, around the disk, the convection is nearly doubled when the disk is at about 150°. At higher temperatures the effect of the cylinder becomes relatively much less. By observing the motion of smoke in the air above the heated disk, it is seen that the air descends along one side of the cylinder, moves across the disk, and rapidly rises along the other side of the cylinder. In general, with vertical surfaces of considerable height, any means of preventing horizontal air currents from flowing in toward the middle portion of the surface, will tend to increase the convection, since it causes the air to be drawn over the lower portion of the surface with very much increased velocity. However, if such flues as are made in this way are too long, the convection again tends to decrease, since the air that comes in contact with the upper part of the surface is already heated by flowing along the lower part of the surface, and is, therefore, capable of taking up very little more additional heat.

The whole subject of flue action in convection is as yet very little understood, and should be the subject of further careful experimental investigation.

CONVECTION IN LIQUIDS—The convection in liquids, in principle, at least, does not differ radically from that in gases. However, the velocity of the currents set up is very much less than in the case of gases, but because of the very great heat capacity of liquids per unit volume, as compared with

gases, the amount of heat carried by convection is usually much greater than with gases. The effect of the viscosity of the liquids is usually of much more importance than in the convection of gases.

The viscosity of liquids, as a rule, decreases very rapidly with increase in temperature, so that the temperature coefficient of free convection in oil is always positive and has a very large value, but differs greatly for different oils.

COMBINED RADIATION, CONVECTION AND CONDUCTION

The heat lost by surfaces is equal to the sum of the heat radiated and the heat carried by convection. It may be of interest to calculate the relative magnitude of these two effects under various conditions. For a surface only slightly above room temperature in air at 20° C., we may calculate the heat lost by convection by determining the amount of heat that would be conducted through a layer of air 4.3 mm. thickness. For 1° temperature difference the heat carried through such a film would be equal to the heat conductivity of the air, i.e., 0.00025, divided by the thickness of the film in centimeters. This gives 0.00059 watt per sq.cm. per C.° as the convection from a body in the neighborhood of room temperature. For a body at 100° C., taking a mean conductivity over this range as 0.000275, we find in a similar way the convection to be 0.00064 watt per sq.cm. per C.°.

From equation (11) the radiation from a black body only slightly above room temperature (20° C.) is 0.00057 watt per sq.cm. per C.°. From equation (8), considering the radiation from a black body at 100° C. in surrounding of 20°, we find the radiation to be 0.00086 watt per sq.cm. per C.°.

The total loss of heat from a surface will be simply equal to the sum of the convection and radiation. For most purposes, it is more convenient to deal with surface resistivities, rather than with surface conductivities. The resistivities are obtained by taking the reciprocal of the sum of the radiation and convection. In the following table are given the surface resistivities of plane surfaces, in three different positions, vertical, horizontal with exposed surface above, and horizontal with exposed surface below. In each case the resistivity at 20° and at 100° is given. Also, the resistivity for the case of a body which does not radiate any heat, and the resistivity for a body radiating as much as a black body. Any actual body will, of course, have a resistivity which lies between these two extremes.

TABLE III. SURFACE RESISTIVITIES OF PLANE SURFACES

Position	20° C.	100° C.
Vertical		
No radiation	1700	1560
Full radiation	860	670
Horizontal, exposed above		
No. radiation	1540	1430
Full radiation	820	640
Horizontal, exposed below		
No radiation	3400	3100
Full radiation	1150	850

There are some cases where the radiation of heat does not play any part in the heat loss from surfaces. For example, in the interior of machines the circulation of air may carry away heat, yet no heat will be lost by radiation. In this case, the surface resistance will be independent of the nature of the surface and will be that given in the table above for a case of no radiation.

The effect of air circulation will always be to cut down the surface resistance, but even with relatively high wind velocities, this effect will never cut it down to less than about one-fifth of its value with no wind.

Another important case, where the effects of radiation and convection need to be separated, is in determining surface losses from a piece of apparatus in a room in which the walls are at a different temperature from the air. It is readily seen that if the average temperature of the walls of a room is 10° above the temperature of the air surrounding the piece of apparatus in the room, the apparatus will receive heat by radiation which it must give up by convection. Since at room temperature radiation and convection are about equally effective in removing the heat from a body which is a good radiator, it is evident that the machine will reach a temperature which is about half way between that of the air and that of the walls; that is, the temperature of the surface of the machine will be about 5° above that of the air surrounding it. Similarly, if the walls are colder than the air, the machine will have a temperature lower than the air. It will be readily appreciated that this effect is by no means negligible, since the walls of a room are often 10° warmer or colder than the air. For example, the roof may be heated by the sun's rays and the air in the whole upper part of the room may be very warm, whereas the air in the lower part of the room may be very much colder. Placing paper or cheese-cloth screens around the machine will almost completely prevent this difference of temperature of the air and machine.

As we have seen, small bodies, such as wires, take up the temperature of the air very much more readily than large bodies, and, therefore, this effect of radiation from the walls will be negligible in the case of wires.

In calculations of the flow of heat through apparatus it is usually most convenient to determine the thermal resistance of the solid parts and simply add the surface resistance. If we then multiply the result by the number of watts of heat flow we obtain the total drop in temperature from the outside of the machine to the air surrounding it. Of course, in actual machines it will usually be very difficult to calculate the thermal resistance of the solid parts. In any case, however, a knowledge of the relative importance of the various factors will be a long step toward the solution of the problem.

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A New Air-Operated Dump Car

For extensive grading work on railway construction and improvement it has become very general practice to use large dump cars of the power-operated side-dump type, having a capacity of 15 to 30 cu.yd., and operated by compressed air from the train-brake system. Equipment of this kind is used largely by railways and contractors, and while its main purpose is to remove and dump excavated material it is employed also to carry ballast, cinders, material for concrete, etc. The use of power operation facilitates the work and reduces the labor cost.

A new car of this type (Fig. 1), which has been introduced recently, has some special features. It is of steel construction throughout, and its general design does not differ greatly from that of other similar cars. The underframe has a single center sill (composed of a pair of channels), which carries the bolsters and end sills and is

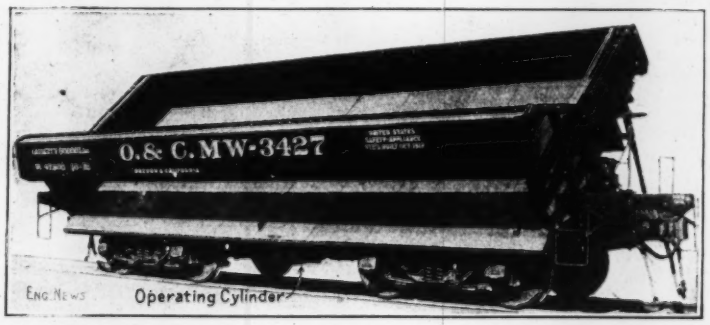

FIG. 1. SIDE-DUMP CAR OF 28-YD. CAPACITY, HAVING THE LOCKING AS WELL AS THE DUMPING MECHANISM OPERATED BY COMPRESSED AIR

(Kilbourne & Jacobs Mfg. Co., Columbus, Ohio, builders)

mounted on a pair of diamond-frame trucks. Upon the sill are pedestals for the bearings which support the car body. The body has four sills of steel angles; each end is formed of three rows of steel channels, and the sides are of steel plate, while the floor is of wood. As is usual in such cars, the sides are not attached to the body, but are carried on hinged arms so arranged that as the body tilts the floor falls away from the side. With this arrangement the flow of material in dumping is unobstructed.

A distinctive feature of the car is in the method of applying the compressed-air power for operating. Cars of this type are operated in two different methods: (1) by a horizontal cylinder on each side (placed longitudinally or transversely), with cables led to the sides of the body; (2) by a vertical cylinder on each side, whose piston thrusts against the bottom of the body. It is this latter method which is employed in the new car. On each

side of the center sill, at the middle of its length, is a vertical cylinder which dumps the body and operates the locks holding it in normal position on the frame. The arrangement is shown in Fig. 2. When air from the car reservoir is admitted to the cylinder *A*, the stops *B B* are raised and operate the locking shaft *C*. The piston rod *D* rises also, and after the locks have been released, its lever connection *E* comes in contact with the lug or block *F*, on the bottom of the car body, and tilts the body. The cylinder on the other side then returns the body to its normal position. The movement of the body is under control, and it can be tilted slowly so as to avoid severe shocks, which is a desirable feature in such work as dumping from temporary trestles.

Another feature is the locking and unlocking of the body automatically by the pneumatic apparatus, as indicated above. In this way the work of uncoupling and coupling side chains on every car by hand at the dumping point is eliminated. However, some makers who have locking systems prefer to use chains to secure the body to the underframe, as a measure of safety, since the accidental unlocking and dumping of a car in a train while running would be a serious matter and might cause derailment, although such an occurrence is improbable.

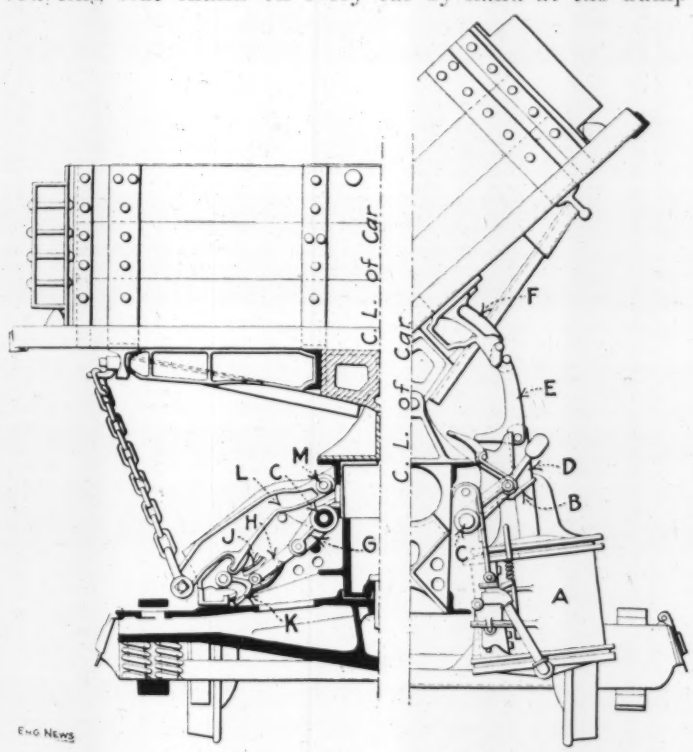

FIG. 2. SECTIONAL ELEVATIONS OF DUMP CAR, SHOWING THE DUMPING AND LOCKING MECHANISM

In the new cars, those of the larger size have the body locked near each corner (Fig. 2). The first part of the stroke of the operating cylinder causes rods to engage arms on the longitudinal shaft *C*, which carries at each end an arm *G*, to which the lock block *H* is attached. The rotation of the shaft draws back this lock in the curved guides *J*. This releases the locking knuckle *K*, which engages the hinged lever *L*, and with the tilting of the car body the chain is free to pull the lever clear of the knuckle as it swings on its pivot *M*. As the body comes to its normal position, the lever *L* is automatically engaged with the locking knuckle *K*. This is then held in place by the lock block *H* when returned to position by the rotation of the shaft as the piston completes its return stroke. It will be seen that these chains are permanently attached, and have not to be coupled and uncoupled like the safety chains noted above.

In the lighter cars, the corner locks are omitted, but near the middle of the car there are two transverse locking bands, semi-circular in form, which pass under the center sill and have their ends attached to opposite sides of the car body. Notches in the inner face of each band engage with locking dogs operated from the longitudinal shaft already mentioned.

In these new cars, therefore, the car body is unlocked, dumped, righted and relocked automatically by the use of air, and the complete operation occupies much less time than when chains on each car have to be uncoupled and coupled by hand. It is stated that one man on any car of a train can control the operation of all the cars, and can dump one car or all the cars, as may be required. The cars can be unlocked and dumped in about ten seconds, and righted and locked in the same time. The reservoir on the car is fed from the train-line of the brake system, and contains a supply of air sufficient to operate the car several times.

As to the performance of these cars, we are informed that a railway company using cars of 20-yd. normal capacity has in routine service handled 30 cu.yd. of cinders per car in a 10-car train, dumping the train on the high side of a curve (using 75 lb. pressure) and being ready to return in less than 20 sec. A railway contractor with a train of 20-yd. cars hauled 25 cu.yd. of stone per car, dumping the train from a 65-ft. trestle without causing injury to the trestle. On another piece of railway work a 10-car train averaging 280 cu.yd. of material is hauled an average of three miles at 35 m.p.h.; and is then dumped, righted and started back in a few seconds. In this way a comparatively small amount of equipment is required to serve steam shovels which are in continuous operation. A steel company has handled 1,500,000 cu.yd. of material with 18 cars in seven months, working 12 hours per day, or about 440 cu.yd. per car per day (190 days).

The cars are built to conform to the requirements of the Master Car Builders Association, so that they may be handled in regular road service. The large cars are of 20 cu.yd. capacity, level full, or 28 cu.yd. maximum load. They are 32 ft. long over couplers and weigh about 47,800 lb. A somewhat lighter car is of 16 yd. capacity (23 yd. maximum). These cars are built by the Kilbourne & Jacobs Mfg. Co., of Columbus, Ohio.

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The Tuolumne River Water Rights of the City of San Francisco were protected by Secretary of the Interior Lane shortly after coming into office by approving maps filed by the city of San Francisco. Secretary Lane has notified the various parties in interest that further than this he would let the Hetch Hetchy matter stand as left by ex-Secretary Fisher, who it will be remembered declined to grant a new permit to San Francisco, but instead insisted that the city should apply to Congress for the rights which it desired. Secretary Lane stated that he thought it would be unbecoming for him to grant a permit in face of the denial by Secretary Fisher, particularly since he (Mr. Lane) has been the original attorney for San Francisco in this very matter some 12 years ago. Secretary Lane said further, however, that he holds the same view now as when he represented the city, and that he would feel free to advise Congress to the effect that, in his opinion, the highest use to which the water of the Tuolumne River at the proposed reservoir site at Hetch Hetchy valley could be put would be to make it serve the purposes proposed by the city of San Francisco.

Construction Work in Madison Square Garden for an Automobile Exhibition

Madison Square Garden in New York City, has been for many years the place of holding those exhibitions requiring a large floor area, such as the Horse Show, the Dog Show, the Sportsmen's Exhibition and the various automobile shows. The building has been so long used that its seating capacity and decorations are much the worse for wear. These conditions, with the frequent need for providing additional floor space, have made it customary to decorate and furnish the auditorium especially for each show.

This work has to be done in the shortest possible time and methods have been developed for doing the work which are worthy of record. The accompanying photographs show the process of transformation of the auditorium, to prepare it for the Automobile Show of 1912. They have been furnished to us through the courtesy of M. L. Downs, Secretary of the National Automobile Show Committee at New York City, and W. W. Knowles, Consulting Architect for the New York Annual Automobile Show.

The method of overcoming the limitations of the Garden with respect to space available for exhibits was by building out temporary extensions to the balcony and gallery. The skeleton framework for these extensions was made of structural steel; the floors, railings, stairs, etc., were of wood. A feature which adds interest to the problem is the limited time available for the work. The Show opened at 8 p.m. Saturday and preparatory operations started at the Garden on the second Thursday preceding. The plan of the work is to first get all the steel erected and, as soon as this is finished, to start putting in the floors of the extensions. The decorations, consisting largely of burlap, bunting, and compo-board paneling, all fireproofed, are started as soon as the floor is in place.

In Fig. 1 are shown views of the work at various stages. The first view, taken Dec. 28, 1911, illustrates the condition of the main floor and balconies at the beginning of the job. In the second view, Dec. 30, the operations have progressed to a point where the structural-steel framework is nearly complete. The laying of the joists for the floor extensions is depicted in the third view, Jan. 1, 1912, and, in the next one, Jan. 2, these extensions are shown practically completed. The finished appearance, after the decorations are hung, is shown in the fifth view, Jan. 4. The last view, Jan. 6, shows the exhibits in place, preliminary to the opening of the show.

The total expense in preparing the auditorium for this exhibition was in the neighborhood of $80,000. The erection of the steel, about 200 tons, cost about $10,000. The floor extensions required 500 M ft. b.m. of lumber and cost $20,000. The expense of the decorations was $40,000, of which $7000 were paid for the big center canopy alone. The running expenses of the Show itself were about $10,000. The fact that much of the construction work was done on overtime, and that everything was sacrificed for speed, accounts for the high costs.

Several years ago the Automobile Show required only small extensions of the galleries and wood framing was used; but the city's building code requires the use of steel framework for the present larger extensions and increased girder spans. This work was done for the 1912 Show by the Grant & Ruhling Co., of New York City, on a contract basis, the steel being furnished by them. The first Automobile Show for which this system of structural steel extensions was used, was held several years ago and this company (under another name) supplied the steel and did the erecting. By marking the pieces and saving them from year to year, the expense of cutting and fitting has been reduced to a minimum and the erection process expedited. As a result of these economies, the same company has secured the contract for this steel framing each year. Their scheme of carrying out the erection is worth brief description.

The steel is brought to the Garden entrances on trucks. At 8 a.m. the doors are opened and the rush begins. The trucks are unloaded and the various pieces placed around the sides of the arena, as near as possible to where they are to go up. Two hoisting engines are rigged up in the center of the arena and hoisting blocks are swung from the roof trusses. Under the direction of a general foreman and four gang foremen, two gangs start from each end of the transverse axis of the Garden and work around the sides toward the ends of the longitudinal axis; 40 men are used in this work. This plan has been found to be the most economical, considering both time and cost. Working continuously day and night, it has been found possible to finish the steel erection in about 45 to 50 hrs.

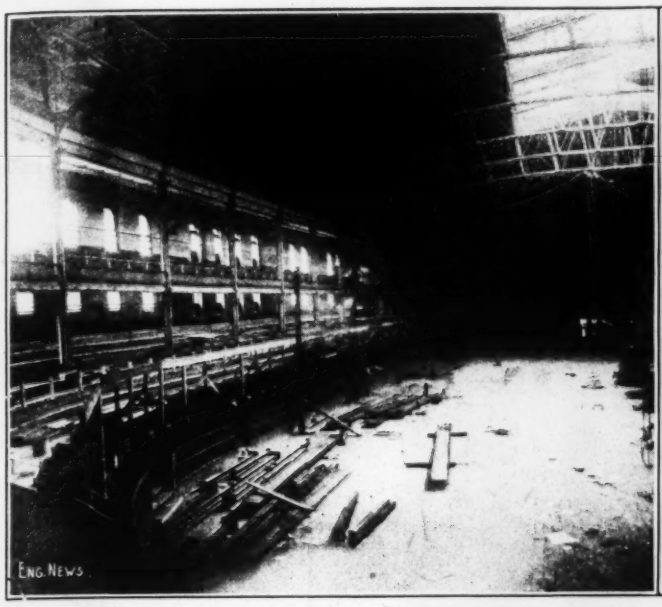
As shown in Fig. 2, the column footings consist of I-beam grillages, encased in concrete, which are sunk in the earth permanently, with their top faces slightly below the level of the main floor (some of the grillages are below the basement floor level). The main columns are 8-in. 32-lb Bethlehem I-beams. The longest girder span measures 38 ft. 2 in. and for this span and the others of nearly equal length 24-in. 100-lb. I-beams are used. The shorter longitudinal spans of 30 ft. or less are bridged with 24-in. 80-lb., and 20-in. 65-lb. I-beams. The inner and outer row of columns, spaced a maximum of 14 ft., are cross-braced by pairs of 5x3x½-in. angles. This steel framework is designed for a maximum combined live and dead load of 125 lb. per sq.ft.

Flooring

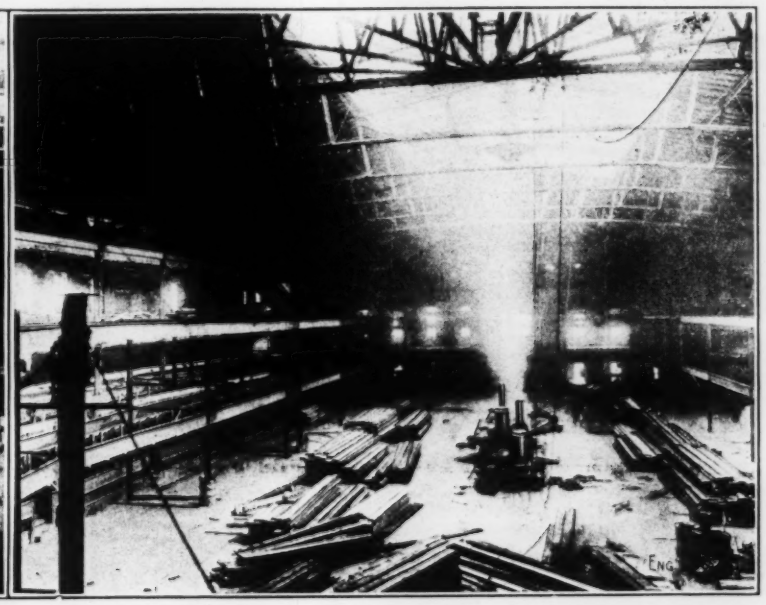
The floors, rails and other woodwork were put in by the Ellison Construction Co., of New York City. Immediately on the completion of the steel work a gang of 150 carpenters began work on the floors. Joists of 3x12-in. timber on 16-in. centers were first put in, extending from the passageway out to a point 9 ft. 4 in. beyond the outside girder, and on these a floor of 3-in. planking was laid. The time required for putting in the flooring and other woodwork was about two days, working, as with the steel erection, continuously day and night.

Decorations and Other Equipment

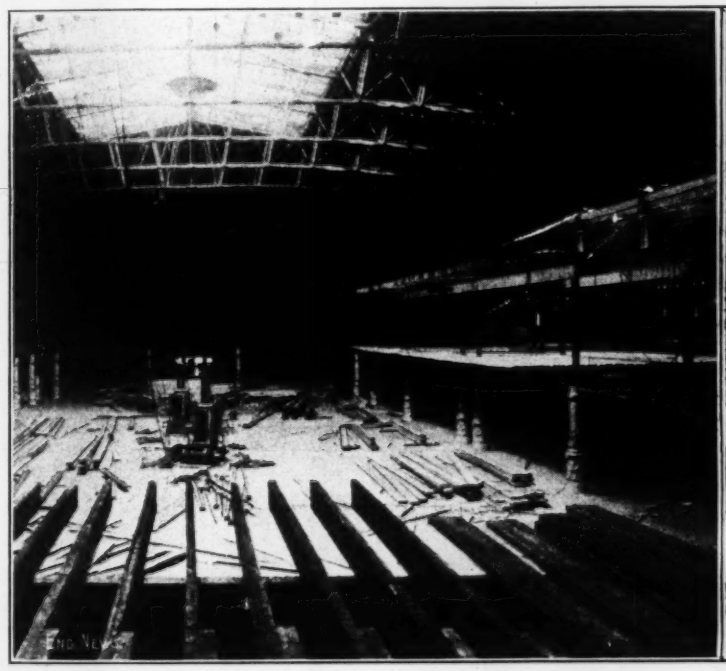
The decorations were designed for uniformity and convenience as well as appearance. The name placards were all of one style and the lettering the same on all. Exhibit spaces were marked by corner posts with illuminated signs all on the same pattern. Hollow cast-iron forms, harmonizing with the other decorations, were placed around the columns. A better idea of the decorative effects can be obtained from the last two views in Fig. 1, than can be given by mere description.



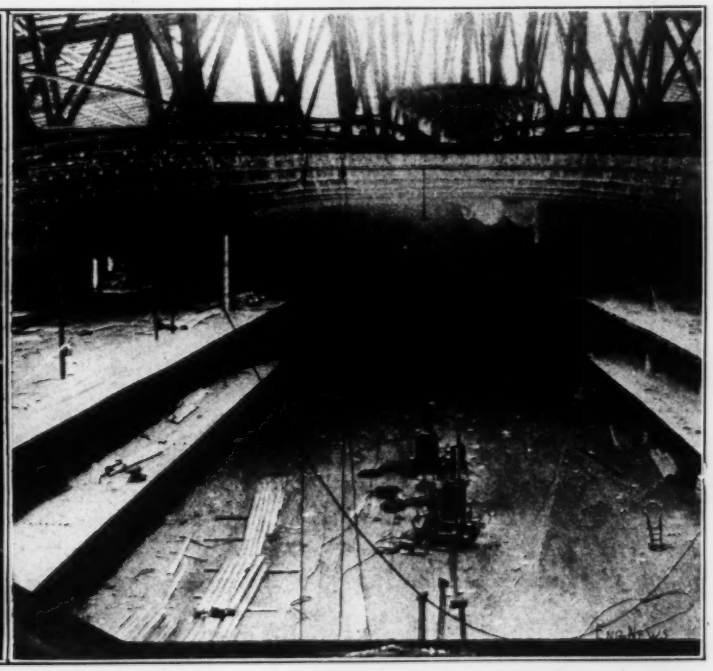
READY TO HOIST STEELWORK, THURSDAY, DEC. 28



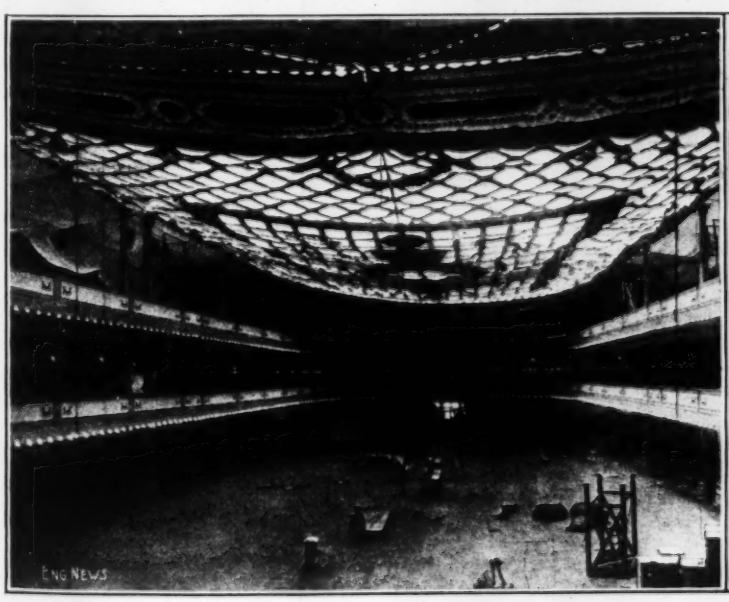
STEELWORK COMPLETED, SATURDAY, DEC. 30



FLOORING PARTIALLY DONE, MONDAY, JAN. 1



FLOORING NEAR COMPLETION, TUESDAY, JAN. 2



DECORATIONS NEAR COMPLETION, THURSDAY, JAN. 4

EXHIBITS IN PLACE, SATURDAY, JAN. 6

FIG. 1. STAGES IN CONSTRUCTION WORK, ANNUAL AUTOMOBILE SHOW, NEW YORK CITY

Two freight-elevators were erected (and later removed) by the A. B. See Co., of New York City, for temporary use only, in hoisting the exhibits up to the extensions and down again. These elevators each had a capacity of 8000 lb. and were each equipped with safety clutch and electric control. They were driven by 220-volt compound direct-current motors. The erection of the two elevators was carried on simultaneously; 12 men did the work in about 36 hours. Work on the elevators was started as soon as the steel frame was completed.

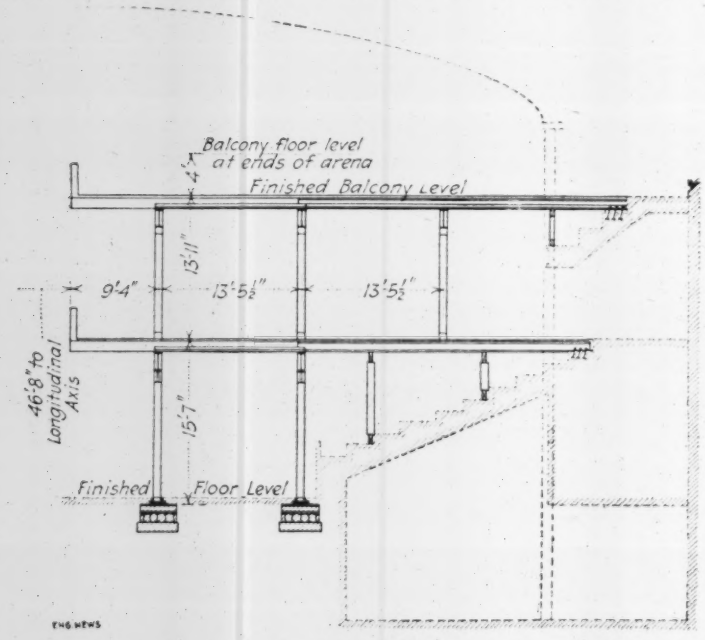


FIG. 2. TYPICAL SECTIONAL ELEVATION OF ONE SIDE OF MADISON SQUARE GARDEN SHOWING THE STEEL FRAMEWORK FOR EXTENSIONS

It is of interest to record that the work of stripping the Garden, after the Show, is compressed into a period of less than 24 hrs. There is more or less rapid action visible in the preparatory work, but the dismantling process represents the superlative, in the line of quick work.

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Contracts Antedating the Establishment of Public-Utility regulation cannot stand in the face of the present powers of a commission under the constitution and the public utilities act, according to a decision of the Railroad Commission of California, now clothed with all usual powers for the regulation of public utilities of the state. The case is that of the city of Palo Alto against the Palo Alto Gas Co. A rate of $1.50 per 1000 cu.ft. of manufactured gas was complained of as being unreasonable. This gas, it appears, was purchased from the Pacific Gas & Electric Co. at a price equal to 50% of the gross income from its sale under a contract made in 1905 for a term of 10 years. The local gas company acts as distributor only. The gas is made 23 miles from the city and other communities along the line are served by the same pipe line. As a result of investigations and hearings, the commission found that the cost of manufacture, transmission and distribution, including 8% on the value of used and useful property, was $1.19 per 1000 cu.ft. In declaring the contract by which gas was purchased void, where in conflict with the findings of the commission, the report notes that, unless the action they take in this case is possible, any utility by entering into contract with third parties for the sale of its commodity would nullify the police powers of the state to supervise and regulate its public utilities.

In fixing the rate for this service the commission holds that it should be at least the average which is earned by other classes of business of the same degree of risk in that community. The commission announces that it must be liberal, lest too strict a policy should turn capital into other fields, while California needs development of its utilities. At the same time, it warns all that great care must be taken not to permit the inflation of property values especially with regard to "going concern."

Steel in Mine Construction*

BY CARL SCHOLZ†

Up to a comparatively short time ago, wood was used entirely for the construction of coal tipples, head frames and buildings on the surface; the only metal used was for the screens, which were of simple design and usually only provided for one separation. Wooden tipples are no longer built, except for very small country mines, and steel and concrete are used almost exclusively for the surface plants.

STEEL FOR COAL TIPPLES

The earlier steel tipples were imitations of the wooden structures, and were much too heavy. Usually 12-in. double channel columns, elaborately laced, were used to take the place of 12-in. square timbers, and this made the cost so high as to prevent extensive adoption of steel. With modern engineering, however, a properly designed steel tipple is no more expensive than a wooden tipple of equal strength, and has so many advantages that there can be no question of the advisability of the use of steel. The elimination of fire risk alone is of much importance. Steel tipples furnish the advantage of placing the supports some distance away from the shaft, and the A-frame type is extensively used. With a tipple of this design the wear of the shaft lining does not affect the structure, because the supports are some distance from the side of the shaft, and caving would not affect the supporting foundations. For fireproof shafts, the three-leg tipple can be used advantageously and at a minimum cost.

Within the last two years the writer developed two new mines, each of which will have a life of approximately ten years. One was a shaft mine and was equipped with a steel tower, with bolted connections, so that after extraction of the coal it can be taken down and removed to another location. The second mine was a slope, and a timber tipple was erected, since this is expected to be the last slope mine which the company will develop, and there would be no further use for the bents. But 13 months after this mine began operation the tipple was destroyed by fire, and the resultant losses would have paid for the steel construction even though it would have been wasted entirely after the extraction of the coal at this locality.

STEEL IN SHAFT LINING

Fireproofing of shafts is regarded as important for safety, and many state laws require such construction. In large and important mines a permanent shaft lining is desirable on account of the elimination of interference in operation due to repairs. Steel frames similar in design to wooden sets for two- and three-compartment shafts have been installed with steel sheeting as lagging. This construction, however, is very expensive. A modified design of a steel shaft lining has been designed by the author and installed at shaft No. 1 of the Consolidated Indiana Coal Co., Dallas, Iowa. In this design the principal members are placed vertically, instead of horizontally, as in the use of timber. Eight I-beams are used; four near the outside corners of the cages; two in the center of the cages, to which the buntings are fastened, and two on the sides, to which the outside guides are fastened; this makes a shaft of elliptical shape. The height of the I-beams ultimately forms the thickness of the concrete lining.

In sinking, the I-beams are fastened together on the outside at intervals of 5 ft., with curved angle irons bolted to the flanges, and thin lumber lagging is used to prevent the caving of material. When the bottom of the shaft is reached, the concrete is put in from the bottom to the top by clamping short form panels to the inside flanges of the I-beams. These inside forms are made from 3 to 5 ft. high. Ordinarily two sets are sufficient to allow of continuous concreting, and are used alternately. In the Dallas shaft this wall is 7 in. thick, and the outside lagging was left in place, with openings at intervals to permit the concrete to tie firmly into the rock surrounding the steel frame.

The advantage of this steel and concrete combination is that the steel can be put in with very little expense and without requiring skilled labor. Sections are bolted together with splice plates. Each section is made self-supporting by having a brace riveted to the outside of the I-beam, which rests in the rock or is supported by a shore or prop safely embedded in the shaft wall. By this means not much attention need be given to the plumbing of the shaft as it goes down, because the steel frames can be shifted to the proper position when the concrete is to be placed. The old method of putting in concrete shafts by the use of wooden forms is

*Abstract of a paper read at the Mining Conference, at the University of Illinois, Urbana, Ill., May 9, 10, 1913.

†President, Coal Valley Coal Co., Chicago.

complicated and requires much skilled labor and involves delay, because the forms must be very carefully set before the concrete is poured in order to have the required alignment for guides and buntings.

In the Dallas shaft the vertical I-beams were made in 15-ft. sections, and in soft material a blind ring (slightly larger than the completed shaft) was used to permit lagging down to the very bottom of the excavation. Whenever the proper depth was reached and a permanent steel frame was installed the temporary rings were removed and the lagging adjusted itself to the permanent bolts. The weight of material in this construction, including 45-lb. steel rails for guides and ¼-in. reinforcement rods 6 in. apart, is about 165 lb. per foot of shaft, and is less costly than the amount of lumber required for the same strength.

STEEL IN MINE WORKINGS

In the mine workings proper much steel is used for various purposes. With the increased weight of cars and motive power the important entries are now laid with 50- and 60-lb. steel rails, in stone ballast. Steel ties are becoming quite popular. At first thought the expense seems prohibitive, considering that a steel tie for 36-in. gage costs about 35c., against a wooden tie costing about 7c. or 8c. But the saving in wages and the reduced number of ties required makes the steel tie more economical under certain conditions. Where the mine bottom is hard, steel ties can be spaced from 4 to 6 ft. apart, enabling the base of the rail to rest on the floor and thus carry the load. The ties principally prevent the spreading of the track. The reduction in height required is of importance in low seams, and the ability to use steel ties over and over again with very little cost for recovery makes the steel ties economical.

Steel I-beams have been used for many years around shaft bottoms and on partings where wide entries have to be maintained. The use of specially made steel props and crossbars is of more recent adoption. Special H-beam sections have been made and found to be economical under certain conditions. The greater strength of steel results in the use of smaller sizes, which require less excavation for the same finished clearance, and the saving of wages in bolting these sets together, as compared with the costly preparation of timber, brings down the first high cost of the steel frames. The rapidly increasing cost of timber and the damaging effect of mine air, which results in dry rot, warrants the investigation of these frames in many localities.

Concrete in Mine Construction *

By A. F. Allard†

Within the last few years many important advances have been made at the modern coal plant in the use of concrete for buildings, shaft lining, walls and construction inside of the mine.

The growing scarcity and steadily increasing cost of large size timbers for inside mine construction makes concrete a welcome substitute, not only for new work, but for the renewal of wooden structures. The stability, permanence and fireproof qualities amply compensate for the increased first cost.

CONCRETE LINING FOR SHAFTS

The adaptability of concrete for this class of work is well recognized, judging by the large number of concrete shafts now being constructed. In fact, we have hoisting and ventilating shafts complete from top to bottom without a piece of timber; the lining walls, cross-buntons, and division wall of the air compartment are of concrete, while the guides and stairways are of steel. The method of sinking mine shafts through soft and water-bearing strata by means of the concrete caisson with a steel cutting edge or shoe has come into extensive use. By reason of its weight, penetration to great depth is possible, rapid progress is made in sinking, the flow of water met with is reduced, and a great saving in cost of labor and material is obtained by the omission of timber curbing.

The cost per vertical foot of a completed concrete-lined shaft is about 33% more than that of the wooden structure. This is the first cost only, for after a few years time the renewal of timbers would be necessary in the latter.

There are numerous designs for concrete shafts, including rectangular, circular, elliptical, and straight sides with circular end walls. The last is a very economical section, utilizing the end spaces for pipeways or stairways and reducing to a minimum the excavation and concrete yardage. The circular end walls have great strength to resist the strata and water pressures, forming a continuous concrete arch from top to bottom; the side wall pressures are taken care of by the thickness of the concrete lining, depending upon the nature and depth of strata penetrated. Generally a self-sustaining material, such as rock, slate or good shale, requires a wall 6 to 9 in. thick, which is sufficient for the anchorage of the buntons. A heavy fire-clay or wet-sand seam would require a much thicker wall.

In the Western iron and coal districts, a number of reinforced-concrete shafts have been sunk through quicksand in water-bearing ground by means of the pneumatic caisson or compressed-air system. This has proved effective in obtaining dry shaft walls and in making a water-tight joint when the concrete caisson reaches the bed rock. Air pressure is maintained until the concrete has set.

SHAFT BOTTOMS OF CONCRETE

The construction of shaft-bottom landings of plain and reinforced concrete includes the single- or double-track entry, providing storage room for loaded cars, space for empty-car lift back of the shaft, and room for empty-car storage track, together with the necessary chutes. For this work, I have used three different designs in concrete construction for supporting side walls and mine roof which have to bear excessive loads and sustain the crushing effect induced by the displacement of the roof strata.

The first is the rectangular section supporting I-beams on concrete side walls and covering with reinforced-concrete slabs, 3 to 4 in. thick. The depth of beam is usually 6 or 8 in. for single-track span and 12 to 18 in. for double-track, the size and weight of beams selected depending upon the nature and condition of the roof. I have placed the beams on 4-ft. centers, covered with slabs 2 ft. wide. The second design is the poured concrete arch with concrete side walls. The third design is the concrete-block arch, composed of plain concrete blocks previously molded in steel forms with joints cut on true radial lines. The blocks are laid up in the arch crown from each side wall, with cemented joints, and are supported on a light frame template until the key piece is placed, and one section of the ring is completed. Provision is made in molding to provide blocks of different lengths for breaking joints on the alternate courses. Blocks 6 in. thick for single and 8 in. for double-track spans and about 18 in. long make a convenient size for the men to handle. This method of arch construction is considerably cheaper than the solid poured section, for it eliminates the cost of expensive forms and time necessary for the transporting and placing of the wet mixture. The rectangular section is convenient at the back of the shaft where it is necessary to provide clearance room for empty-car lift and where going up into the roof with an arch of large span would prove expensive.

The poured arch section is generally adopted for a distance of 10 to 15 ft. on each side of the shaft, the work connecting into and supporting the shaft walls. The continuation of arch with concrete-block construction for the main landing and empty runarounds, makes an ideal and fireproof shaft bottom.

*Abstract of a paper read at the Mining Conference held at the University of Illinois on May 10 in connection with the dedication of the Mining Laboratory.

†Chief Engineer, Bunsen Coal Co., Danville, Ill.

The Operation of the Chicago Elevated Railways as one complete system, with through routes and through trains, is being demanded by the city as a means of increasing the traffic capacity and relieving the very serious congestion of the terminal loop. The four original companies have been consolidated and are controlled by a single company with one set of officers, but they are still operated as distinct units. Separate fares are charged and there are no transfers, so that passengers having to use two of the connecting lines have to pay two fares. The trains of the four lines enter the terminal loop at different points, and each train passes entirely around the loop, leaving it at the same point at which it entered. The number of trains is so great during the busy hours, and the delays at the stations and junctions are so numerous, that the speed is extremely slow, thus cutting down the average speed between outlying stations and points on the loop. It has long been urged that the use of the loop as a universal terminal should be abandoned, through trains being run between the north and south sections of the city, while trains entering from each of the two west-side lines could pass around a portion of the loop and depart over the other line. A few structural changes would be necessary to change the present track connections, and as two of the lines run on the left-hand system their car equipment would require some changes to adapt it to right-hand running. The railway company, however, seems disinclined to make the changes in operation unless the city grants certain concessions.

Direct-Lift Drawbridges without Cables

SYNOPSIS—The two articles following describe different designs for a new type of drawbridge in which the span is raised vertically but without the aid of cables either for the operating system or the counterweight system. The operation is by rack-and-pinion gearing, and the counterweights are carried by lever systems, attached to the lift span and pivoted over the towers. Some bridges of this type are already under construction, and the articles describe several modifications of the general design, adapted to meet varying conditions.

Within the past few years the vertical-lift type of drawbridge has been regarded with some favor, and a number of bridges of this type (large and small) have

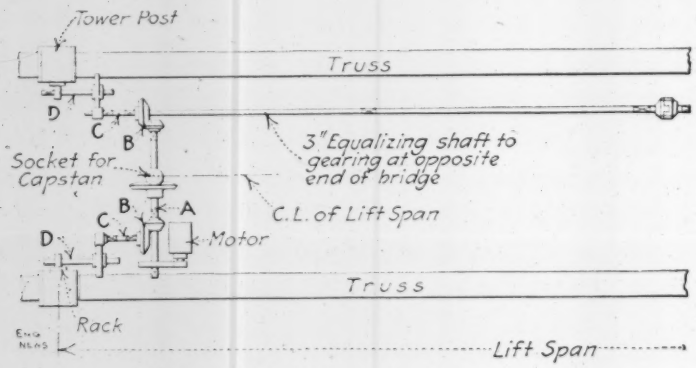

FIG. 1. OPERATING MACHINERY OF THE DIRECT-LIFT SPAN (STRAUSS SYSTEM) OF THE ARKANSAS RIVER BRIDGE, NEAR PINE BLUFF, ARK.

been built for both railway and highway purposes. Up to the present time all these bridges have been operated by cables and winding drums, the moving span being balanced by counterweights suspended from other cables. All these cables pass over sheaves on the top of high towers erected on the piers or abutments of the lift span, and between which the span moves. There are certain objections, however, urged against the cable system of operation, such as the possibility of breakage, the cost and trouble of renewing the cables, the adjustment for stretching, and the general care of the cables and sheaves. To avoid these objections, a direct-lift type of bridge has been designed, in which the operation is effected by pinions engaging with vertical racks on the tower posts, while the counterweights are carried by lever systems. Lift bridges of this type have been invented and patented by J. B. Strauss, engineer, of Chicago, and the Strauss Bascule Bridge Co. already has contracts for the design of some of these structures. The general type is capable of various modifications to meet special conditions.

Among the advantages claimed is the fact that the support of the lift span at points between its ends reduces the dead-load stresses and permits erecting the span in the open position when necessary without the use of falsework. This would avoid the trouble of building the span at a distance from the site and then floating it into position, or handling it in similar ways. In such case, the hanger points may be used as points of support from which the trusses are built out as cantilevers until they meet and are connected at the center.

Operating Machinery

The bridge is operated by spur pinions on the lift span which gear with vertical racks on the tower posts. The racks may be on the inside or outside face of the post, according to the detail requirements in each case. Fig. 1 shows the arrangement of the machinery on the Arkansas River bridge, the racks in this case being on the outer sides of the posts. The 25-hp. motor drives a cross-shaft *A*, on which are mounted three bevel gears. Two of these are bevel pinions, *B*, *B*, driving short individual countershafts *C*, *C*. These carry spur pinions which drive the operating shafts *D*, *D*, on which latter are the rack pinions. The third bevel gear on the cross-shaft engages with the pinion of a vertical shaft (on the center line of the bridge) having a capstan head, for operating the bridge by hand. The motor and gears are in duplicate at each end of the bridge, and to insure uniform action two of the countershafts are connected by a longitudinal equalizing shaft. On this last is a motor-driven emergency brake, which will check the motion in case of any accident to the counterweight system.

In this bridge, the 245-ft. lift span will weigh about 500 tons, and can be raised or lowered by the machinery

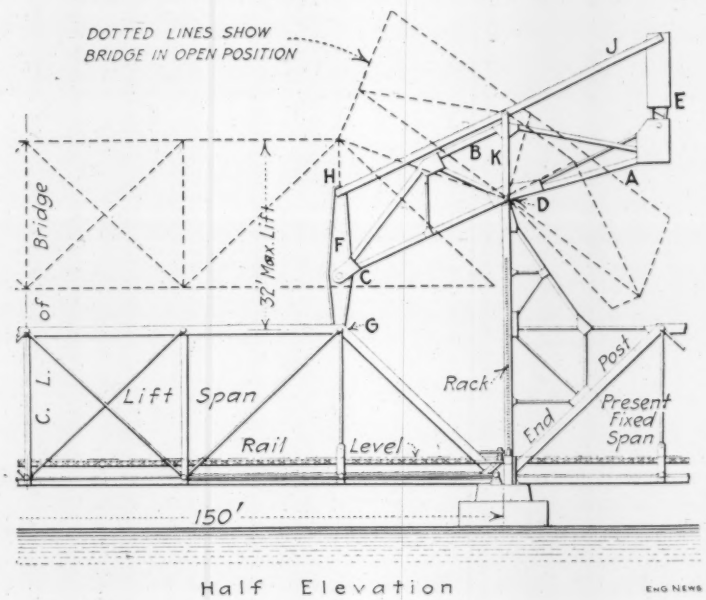

FIG. 2. COUNTERWEIGHT SYSTEM FOR DIRECT-LIFT DRAWBRIDGE (STRAUSS SYSTEM)

in about one minute, or by hand in about 50 minutes. The ratio of the gearing is as follows:

	No. of teeth	Pitch diam. in.	Pitch	Width of face in.
Motor pinion	18	15.14	3½ d.p.	3¼
Cross-shaft gear	126	36.00	3½ d.p.	3¼
Cross-shaft bevel pinions	20	10.00	2 d.p.	4
Countershaft bevel gear	60	30.00	2 d.p.	4
Countershaft pinions	15	8.36	1¾ in.	3½
Operating shaft spur gear	52	29.00	1¾ in.	3½
Operating pinion	15	11.94	2¼ in.	6¼
Operating rack	240		2¼ in.	3½
Bevel pinion on hand shaft	16	12.72	2½ in.	3¼
Bevel gear on cross shaft	24	19.08	2½ in.	3¼

Counterweight System

While the operation of the bridge by rack and pinion is extremely simple, the counterbalancing of the span in all positions is, at first sight, more involved. The ar-

rangement of the counterweight system is shown in Fig. 2. Upon the tower or bent, is carried a rocking counterweight truss *ABC*, supported by the trunnion pin *D* at the top of the tower. The rear end of the truss is attached to the lower part of the counterweight, *E*, while the forward end is attached to a vertical hanger *F*. The lower end of the hanger is attached to the bridge span at *G*, and its upper end is attached to a link *H-J*, whose rear end is attached to the upper part of the counterweight *E*. Part of the weight of the link is carried by a vertical strut *K*, pivoted to the link and to the trunnion pin of the truss at *D*.

Thus the counterweight, truss, hanger and link form a jointed frame, which is so proportioned as to meet the requirements for perfect balance as follows: (1) That for all positions of the lift span the sum of the moments of all the forces about point *D* (the trunnion at the head of the tower) must equal zero; (2) the moment of the counterweight about the point *A* (at the counterweight end of the rocking truss) must be equal and opposite to the combined moments of the lift span, hanger and link about the point *C* (at the bridge end of the rocking truss). With this system the bridge is balanced in all positions, and the main trunnion reaction on the post of the tower or bent is constant and always vertical.

This type of bridge lends itself especially to cases where a fixed span has to be converted to a draw span. These cases may arise from the development of navigation on a stream crossed by a fixed bridge, or by the shifting of the navigable channel from the original draw span to one of the fixed spans (as sometimes occurs).

Arkansas River Bridge

The second case (or the possible necessity of shifting the draw span from its original location to another span of the bridge) is represented by a combined railway and highway bridge over the Arkansas River near Pine Bluff, Ark. This bridge will carry a steam railway and electric railway (on one track), with two roadways and two sidewalks, outside of the trusses. It will have six through-truss spans of 245 ft. and an end span of 140 ft., besides long trestle approaches. As built, the first 245-ft. span will be a lift span on the Strauss system, with towers carried by the piers and the end panels of the adjacent spans. The lifted weight will be 500 tons. The maximum lift is 50 ft., giving a clear headway of about 60 ft. above high water.

Should the channel shift from its present location, the towers and the operating and counterweight mechanism can readily be moved to any one of the other spans. To provide for such a change, the towers are so made that they can be disconnected at the top chords and moved along these chords which would serve as a track. To facilitate this also, the counterweights are made in blocks of such size as to be handled by one man, so that they can be removed and replaced readily when it is necessary to shift the towers. That such a movement is not improbable is shown in an article on drawbridges by C. E. Smith, in our issue of Jan. 23, 1913. This referred to two other bridges over the Arkansas River in which provision is made for the shifting of the navigable channel, and the article referred also to the advantages of the vertical-lift type of drawbridge under such conditions. The Roemheld Construction Co., Chicago, has the contract for the Pine Bluff bridge.

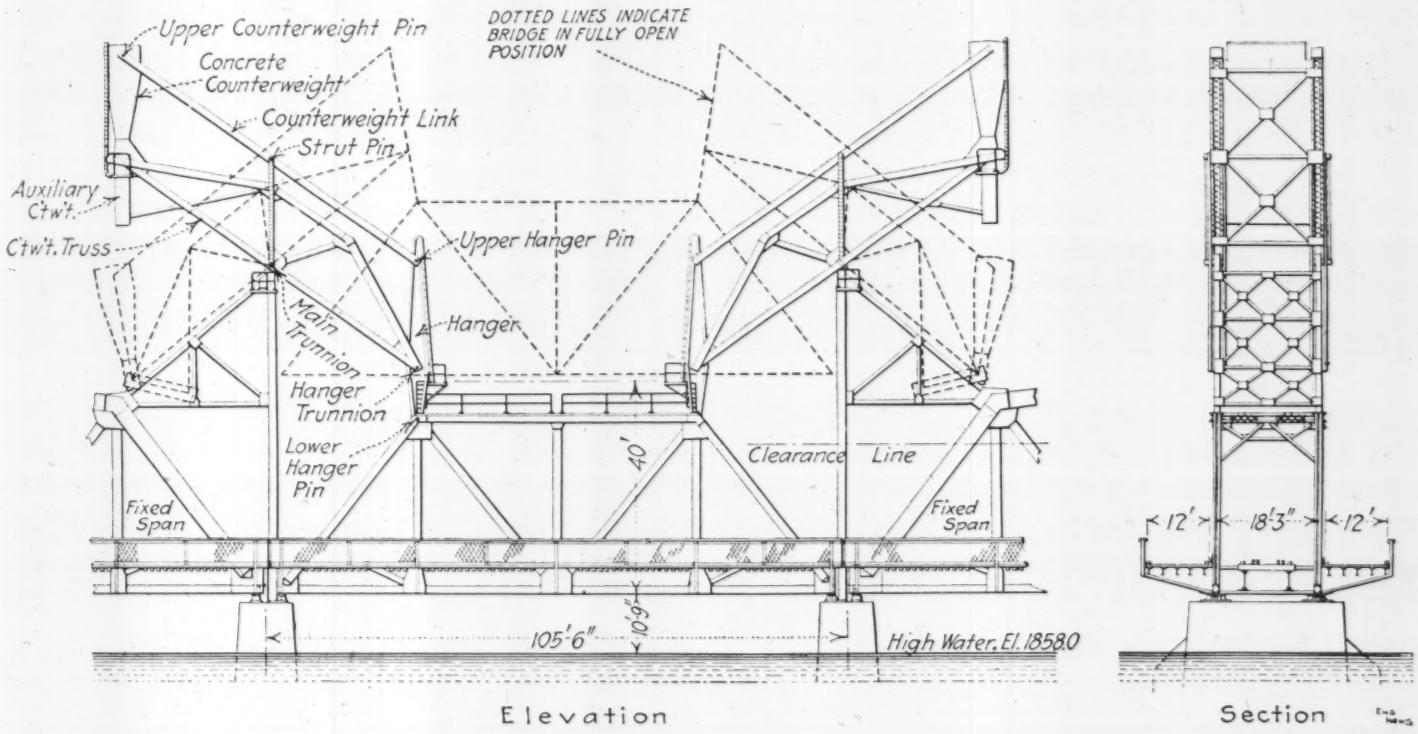

Fig. 3. Direct-Lift Span of Combined Railway and Highway Bridge over the Fraser River; Grand Trunk Pacific Ry.

(Strauss Bascule Bridge Co., Designer, Canadian Bridge Co., Contractor.)

Steilacoom Creek Bridge

This direct-lift bridge is to be built to carry the Northern Pacific Ry. over Steilacoom Creek, near Tacoma, Wash. It will be a double-track riveted pony-truss lift span of 96 ft., with trestle approaches. An un-

usual feature in this case is that the towers are connected by overhead struts, for the reason that they are carried only by the piers and cannot be braced from the trestle. The lift in this case is about 43 ft. 6 in., giving a clear headway of 50 ft. with the bridge raised. The lifted weight will be 155 tons. The American Bridge Co. has the contract for this bridge.

Fraser River Bridge

For the channel span of the combined railway and highway bridge to be built by the Grand Trunk Pacific Ry. over the Fraser River near Fort George, B. C., the Strauss direct-lift system has been adopted. This lift-span, shown in Fig. 3, will be a 100-ft. riveted through-truss span, with towers supported on the piers and adjacent fixed spans. It will carry a single track line and two 12-ft. roadways. The weight of this span will be about 200 tons. Its lift will be about 40 ft., giving a clear headway of 50 ft. when raised.

The Canadian Bridge Co. has the contract for the superstructure of this bridge. A duplicate of this structure will be built over the Nechako River for the same railway.

Proposed Modified Designs

Several designs have been prepared to adapt this type of bridge to meet special conditions. One of these provides for a much greater lift than those mentioned above, and is a design for a double-deck (street and elevated railway) bridge over the Chicago River at Lake St. The lift would be about 104 ft., giving a clear headway of 120 ft. with the bridge raised. This, together with the great weight to be carried, would necessitate heavier towers, and each of these is designed as a four-post braced tower on cylinder piers. The span would be 244 ft. c. to c. of piers (200-ft. channel) and the weight of lift span about 930 tons. Another design for this bridge provides for its operation from one tower only, the span length being 218 ft. and the lifting or hanger attachment being near the center of the span. This would weigh about 660 tons.

In another design, proposed for the 12th St. bridge over the Chicago River, the counterweight trusses form part of a suspension system, from which the live load is carried. The connections at the hangers would permit their movement without disengagement from the suspension truss. This design is said to be specially adapted for bridges of ornamental character.

In bridges with the floor high above water level, yet not sufficiently high for navigation, the counterweight system may be mounted beneath the level of the lift span. The same arrangement may be applied also for canal bridges, where space is limited and the lift is small. In this latter case, the counterweight system is arranged to be mounted in masonry pits below the ground, with the counterweight trusses placed at right angles to the line of the bridge. For such bridges, stairs may be erected on the abutments to provide for foot traffic while the span is raised.

Finally, for short plate-girder lift spans, a design has been made which dispenses with towers, each trunnion being mounted on a single post, braced from the pier. In this design, the hanger attachment is made at the bottom flange of the girders.

A Vertical-Lift Drawbridge without Cables

The vertical-lift type of drawbridge has received a considerable amount of attention within recent years, as noted in a preceding article, but while the existing bridges are operated by means of cables, we describe herewith the design of a vertical-lift bridge which is supported and operated without cables or chains. This type of bridge is said to be particularly adapted to and economical in cases where the height of travel or lift is not great, although it can be applied where the lift is as high as 150 ft. The design described below was developed by the Strobel Steel Construction Co., of Chicago, which controls patents covering the general design and specific details, and we are indebted to the engineers of the company for information, as well as for drawings showing different applications of the design. One bridge of this type is already under contract.

The principle of the design consists in suspending the lift span from pivoted and counterweighted lifting trusses which move on trunnions supported by towers at the end of the span. On the vertical posts of the towers are racks engaging with operating pinions on the lift span. This general type of construction is shown in Fig. 1, in which four-post towers support the lifting trusses *A-B*, having one end pivoted to the lift-span and the other end provided with a counterweight. In order to provide for the radial movement of the lever arm attached to the bridge, the trunnion-bearings *C* are fitted with rollers and have a horizontal travel on a track girder at the top of the tower, so that the point of attachment *B* will travel in a vertical path. With the bridge lowered, the trunnion of the lifting truss is at the forward end of its track. As the bridge rises the trunnion rolls backward, reaching the limit of its travel when the bridge is at mid-height; as the bridge continues to rise, the trunnion rolls forward again, reaching the limit of its travel when the bridge is lifted to its extreme position.

One end of the lift span is guided both longitudinally and laterally, while the opposite end is guided only laterally, thus providing for expansion of the span. The operating mechanism is mounted on the lift span, and has bevel-gear connections to a longitudinal shaft which carries the operation pinions.

In Fig. 2, this vertical-lift system is shown as adapted for cases where an existing fixed span must be converted into a movable span in order to provide for navigation and where the adjacent spans must not be loaded by the lifting apparatus, but the weight must be carried directly by the piers. This is effected by carrying the lifting truss *A-B* on a vertical bent *C*, on each pier, and braced to the adjacent span. In this case, however, no longitudinal movement of the trunnions is practicable and the trunnions are carried in fixed bearings at *D* on top of the posts. The necessary longitudinal travel to compensate for the radial movement of the lever arm is provided, therefore, at the point of attachment of the arm (or lifting truss) to the lift span. At this point an additional member *E* is built upon the bridge truss, and carries beneath it a track plate *F*, against which bears the roller *G* at the end of the lifting truss. The operation will be understood readily from the dotted lines, which show the curved path of the rollers and the vertical path of the bridge.

In the designs shown in Figs. 1 and 2, the lifting apparatus is provided at both ends of the bridge. A modified design in which the bridge is operated entirely from one end is shown in Fig. 3. In this design, also, the operating machinery is carried upon the tower instead of upon the bridge. In this case, the bridge in moving vertically has a longitudinal and horizontal movement, swinging in a vertical arc due to the radial movement of the arm of the lifting truss. This truss *A-B* has a fixed trunnion on the head of the tower at *C*, and a pin attachment to the lift span at *B*. To hold the span in a horizontal position while moving, the end of the bottom chord of the span is attached to the controlling strut *D-E*, the rear end of which is pivoted to the tower. Thus, as the lifting truss rises, the bridge is suspended from the pin *B* at the end of the top chord and supported longitudinally by the pin *D* at the end of the bottom chord.

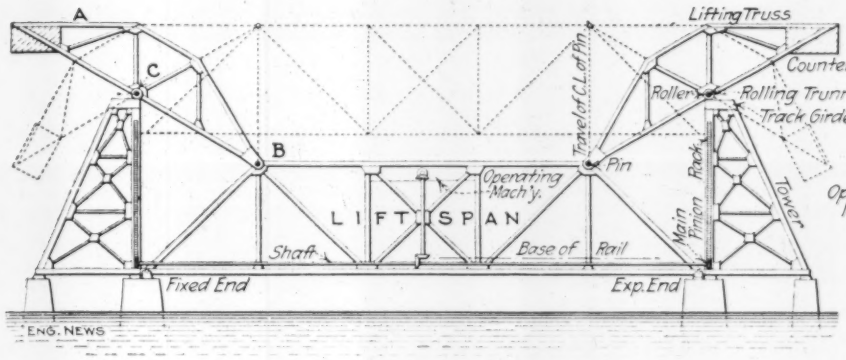

FIG. 1. DESIGN OF VERTICAL-LIFT DRAWBRIDGE WITHOUT CABLES

(Strobel Steel Construction Co., Chicago.)

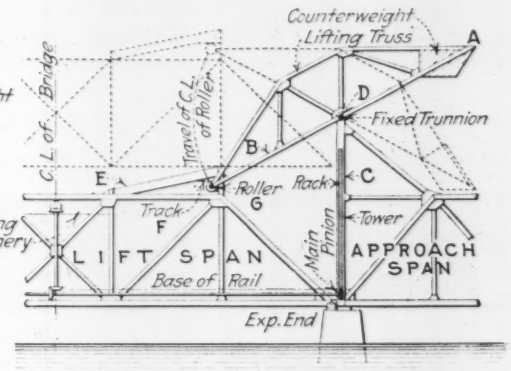

FIG. 2. VERTICAL-LIFT ARRANGEMENT (STROBEL SYSTEM) AS ADAPTED FOR CONVERTING A FIXED-SPAN TO A DRAW-SPAN

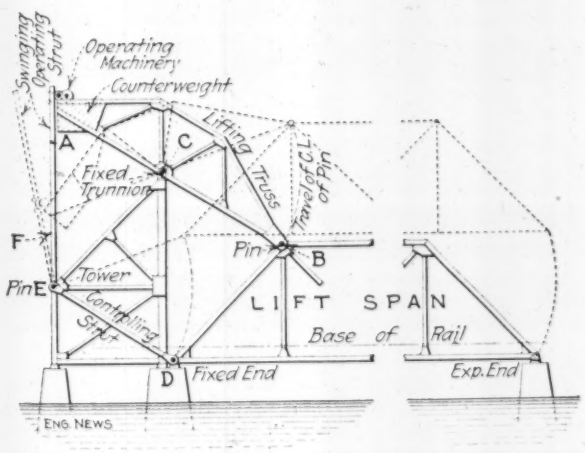

FIG. 3. VERTICAL-LIFT ARRANGEMENT FOR OPERATING A BRIDGE FROM ONE END (STROBEL SYSTEM)

The operating mechanism is different from that of the other designs. It is carried on the counterweighted or tail end of the lifting truss, at *A*, and serves as a part of the counterweight instead of adding to the weight to be lifted. The pinion engages with a rack on a vertical operating strut *F*, which is pivoted to the rear post of the tower. As the bridge rises, the pinion rides downward on the rack, the strut swinging outward to accommodate the curved path of travel of the pinion, as shown.

An alternative arrangement proposed is to put the trunnion bearing of the lifting truss at *E* and to attach this truss to the bottom chord of the lift span, while the controlling strut would be pivoted to the head of the tower and the top chord of the lift span. In other words, the positions of the lifting truss and controlling strut in Fig. 3 would be reversed. A second alternative is to replace the controlling strut by a second lifting truss, which would be somewhat similar to the arrangement employed for the Frederick Bridge at Dresden, Germany.

A LONGITUDINAL-MOVEMENT DRAWBRIDGE

The temporary removal of a fixed span (to provide for infrequent navigation) by a derrick car which raises the bridge and runs it back longitudinally, is familiar to engineers, and was noted in our issue of Jan. 23, 1913. It is not generally known that designs were made some time ago for the regular operation of a drawspan in this way, the part of the derrick car being taken by counterweighted lifting trusses carried by trunnion bearings on a tower traveling on tracks outside of the line of the bridge girders. By rocking the trusses on their trunnions the bridge would be raised clear of the abutments, and the towers would then be run back sufficiently to carry the bridge clear of the opening. This design was invented and patented by Mr. Strobel, and is worth mention here, although the design has not been carried into practice.

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The West Virginia Public-Utility Law which goes into effect soon provides for four commissioners, each with an eight-year term of service and a salary of $6000. The commission is given jurisdiction over the usual common carriers, over gas and electric companies, telegraph and telephone companies, and over municipalities furnishing gas or electricity. The jurisdiction is specifically extended over car companies, toll bridges and ferries, hydroelectric generating and transmitting companies, water companies, and persons, associations, corporations, or agencies employed in the several businesses noted. The commission also has to perform duties in connection with any workmen's compensation law which may be established. It has the usual power over rates and service, except that it cannot reduce any rates within ten years after the completion of a road or plant below a point which would prevent the owning corporation from making a net earning of 8% on the cost of construction and equipment. The commission is instructed to collect full and complete data on the value of all property owned and controlled by these corporations once a year, and to furnish this information to the Board of Public Works for tax assessments. The new law lays a new tax on public-service corporations by a special license fee proportioned to the value of the corporation's property. This tax is to be distributed so that its aggregate will produce a revenue of $60,000 a year for the support of the commission.

Origin and Theory of the Pitot Tube

By A. E. Guy*

The essay of Mr. John Airey, "Notes on the Pitot Tube," which appeared in Engineering News, Apr. 17, 1913, suggests several points worth examining into at this time, because the value of the Pitot tube is now well recognized and the instrument is consequently much in favor. These points may be enumerated as follows:

A—Authorities on hydraulics are at variance as to the kind of tube the French engineer, Pitot, did *use*, discover, or *invent*. All are unanimous in stating that he brought forth a single tube bent at the lower end; many state that the bent end of the tube was in the form of a funnel.

B—Did Pitot establish a theory for his instrument?

C—Should the theory be based on the consideration that the column of water in the tube is sustained by the impact of a jet of water of cross-sectional area equal to that of the pipe, in which case $h = K\frac{v^2}{g}$ (K being a coefficient to be determined by experiment)?

D—For perfect flow conditions the velocity head is undoubtedly $h = \frac{v^2}{2g}$; then what is the theory which could logically conduce to this result without resorting to imaginary and, therefore, unexplainable action between the streams coming into contact with the tube?

E—Is the theory offered by Mr. Airey logical and therefore acceptable?

1. As to *A* and *B*. The first point involves a difficulty of but minor importance, viz., that of translating into English the original description of the tube as presented to the Royal Academy of Sciences of Paris by Pitot himself, under date of Nov. 12, 1732. The description is printed *in extenso* in the "Memoirs of the Academy," along with an engraving showing the complete instrument, that is, the two tubes mounted on a piece of hard wood of triangular cross-section, each side of the section being about 1½ in. long; showing also the tubes separate, that is, one straight and one bent at the end, and a sliding gaging scale, on one edge of which are engraved the division lines for measuring the head proper, while on the other edge are corresponding division lines for reading at once the velocity. A photographic reproduction of the original engraving is given here in Fig. 1.

Pitot begins his paper by bemoaning the fact that practically the only method before used for measuring the velocity of streams in rivers and canals was productive of doubtful results. He analyzes briefly that method, consisting in measuring the velocity of a floating object, and then discloses the details of a novel apparatus which he has had constructed and with which he made some very successful tests. He also reports a discovery of the first magnitude made by use of the new device, viz., that the velocity of a stream is not the same at the surface as at some point below, and furthermore, that the velocity decreases as the depth increases, which was contrary to the opinion accepted from the Italian engineers, then recognized as the most advanced in Europe as regards knowledge of the motion of flowing streams. They held that in a river the velocity of the molecules is proportional to the mass situated vertically above them, and consequently that the velocity increased with the depth.

Pitot placed the straight tube with the lower opening near the flat base of the wood support; and the other tube had its bent branch engaged into a groove at the base of the support, the extremity of the branch reaching close to the thin edge of the triangular cross-section, and in line with the opening of the straight tube. In order to facilitate the reading of the instrument the back of the tubes, close to the support, was coated carefully with white-lead paint.

For measurements corresponding to a given depth the sliding scale was adjusted so that the zero mark corresponded to the depth, then the instrument being immersed up to that mark the water rose in the bent tube to a height which could be read on one side of the scale and corresponding to which the velocity was read on the other side of the scale. On page 370 the description reads:

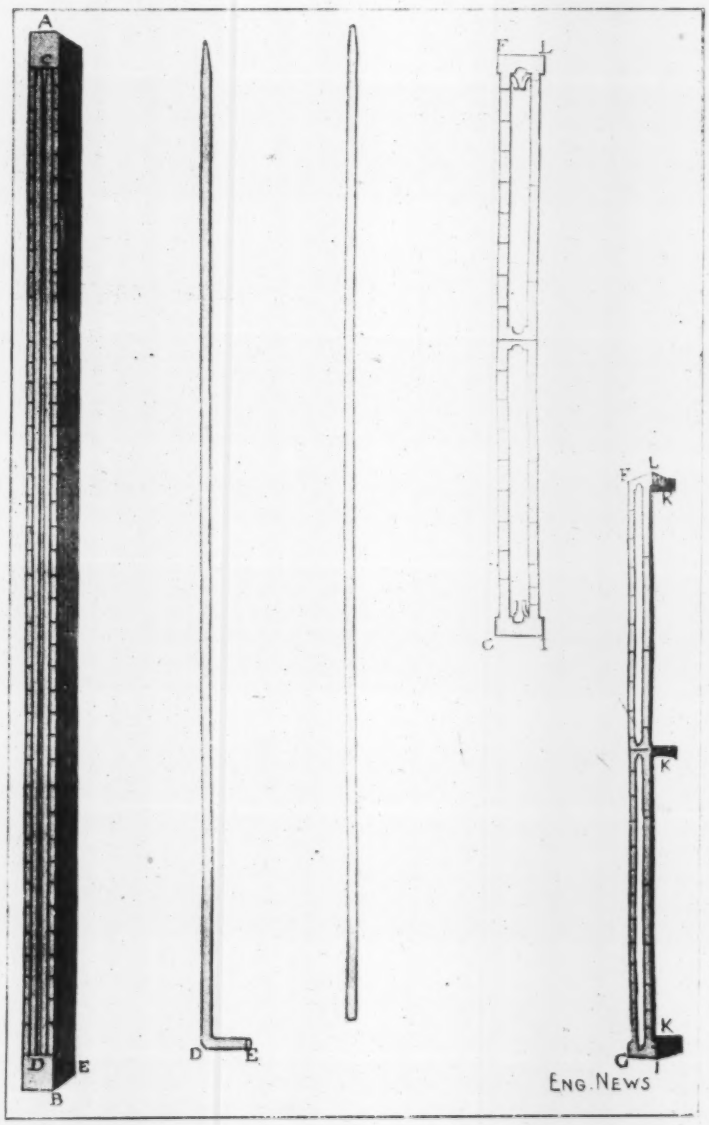

Fig. 1. Pitot's Original Illustration of the Pitot Tube

(Photographed from plate illustrating his paper, in Memoirs of the Royal Academy of Sciences, 1732.)

> The force impressed by the velocity is always equal to the weight of a prism of water, the cross-sectional area of which would be the same as that of the surface impinged upon and whose height would be the same as that from which the water would have had to fall in order to acquire that velocity. Hence the water should ascend in the tube of my machine, through the force of the current, precisely to the height from which it should have dropped to form that current.

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That is all the theory disclosed by Pitot. He arrived at it through very simple reasoning, thus: A head of water produces a certain velocity (this was well known then, having been fully demonstrated); conversely, says he, a given velocity should produce the head indicated by theory. On page 371 of the Memoirs he states:

> The principle of this instrument is so simple and so natural that as soon as I conceived the idea I ran at once to the river to make a preliminary test with one simple glass tube, and the result responded perfectly to my expectations. After this first trial I could not imagine that a thing so simple and at the same time so useful had escaped the attention of so many skilled men who had written and worked upon the subject of the flow of water. I have since searched exhaustively through all the treatises on Hydraulics which I have been able to find, in order to discover whether anyone had disclosed it before, and to make sure that consequently my conception is novel.
>
> At the precise time when I made the first test in the river I also conceived the application of my idea to the measure of the speed of vessels; indeed, the feasibility of this important application is too obvious to fail presenting itself at once, and before sending my Memoir to the academy I have meditated at length upon the means to render practical the applications for sea service, and to avoid all the irregularities that might develop, either from the different motions of the vessel or of the waves.

He then proceeds to describe what thus far he considers the best method, which consists in locating two tubes through the hull at some distance below the water line; one of these tubes having its opening flush or parallel with the axis of the vessel; the other having a bend directed toward the bow, "*with a flaring opening, as in my machine.*" These tubes extend conveniently inside the vessel, where they are each connected to a glass tube. With the vessel at rest the height of water is the same in both tubes, but with the vessel in motion there is a great difference between the two heights, and the difference is precisely, according to Pitot, the head corresponding to the speed of the vessel.

Thus far it is clear that the instrument invented by Pitot consisted of a combination of two tubes, one straight and one bent; as shown by the engraving accompanying his Memoir the opening at the bent end was not funnel-shaped, but it may have been slightly flared to conform with the supposed requirements of boat service; the theory advanced by Pitot was axiomatic, hence assumed to be so obviously correct as to require no further demonstration.

In *Encyclopedia Britannica*, section on Hydromechanics, Vol. XII, p. 507, Prof. Unwin says of the Pitot tube:

> A very old instrument for measuring velocities, invented or used by Pitot, consisted simply of a vertical glass tube with a right-angle bend, placed so that its mouth was normal to the direction of flow. . . . . Pitot extended the mouth of the tube so as to form a funnel or bell mouth. In that case he found by experiment $h = 1.5 \frac{v^2}{2g}$.

There can be no question that Pitot did not merely use, but invented the instrument. As a brief digression, we might observe in this case the clear difference between invention and discovery. Thus, Pitot conceived a new theory, thought out means in which to embody it for practical use, and having further conceived the idea of the bent tube, he hastily made such a tube and ran to the nearest spot to experiment with it. This spot was between the piers of a bridge on the river Seine at Paris. He finds the velocity of the current corresponding to the head measured on his tube, realizes that his idea is correct, and with the addition of a straight tube, completes the invention. With the perfected instrument plunged at different depths at the same spot in the river, he then discovers that the velocity of the current decreases with the depth of the river.

As to Prof. Unwin's statement regarding the value of h, we may refer to the "Treatise on Hydraulics" by d'Aubuisson (Paris, 1834); on p. 144, the last paragraph, translated, reads as follows:

> This height measures well enough the sum of the pressures exerted upon the orifice of the tube; but the pressure exerted upon a body immersed in water is dependent upon the form of the body, as will be shown later. Furthermore, the pressure of the various streams composing the striking mass goes on diminishing from the center to the circumference in such a way that one single stream, the central one, for example, must be isolated; and besides, the form of the tube must be experimented with. Chevalier Dubuat, author of the foregoing observations, found that by shaping the orifice as a funnel, the opening of which is closed by a plate having a small hole at its center, two-thirds only of the elevation of the fluid in the tube represented the height due to the velocity, and that consequently $v = \sqrt{2g\,(\frac{2}{3}h)}$, h being the height of the water in the tube above the surface of the current.

From this we get $h = 1.5 \frac{v^2}{2g}$, but we see now that this result was obtained by another hydraulician, the well known Chevalier Dubuat, and obtained by means of a modification of the Pitot apparatus.

It seems that after Pitot had disclosed his invention, many investigators used the bent tube only, thinking the straight tube unnecessary. Furthermore, having no exact means for controlling their measurements, and the indications of the tube being at times in discordance with those of the float method, it came to be that the tube fell into disfavor with the investigators. Some, like Dubuat, attempted to modify the form of the orifice. And so it came to be regarded as a rather interesting instrument, but one that could not be relied upon without very exacting calibration, and even that had but a limited field of application.

In 1856 Darcy published his great work, "The Water Works of the City of Dijon," in which he described among the gages be used a novel form of the Pitot tube, which became known thenceforward as the Darcy tube. Even that is variously described by recent writers as being like Fig. 2, Fig. 3, or Fig. 4. Prof. Rateau (*Annales des Mines*, March, 1898) in a most remarkable paper on "Experiments and Theories on the Pitot Tube and the Woltman Mill," is himself led into error, evidently through the memoir of C. Ritter (*Annales des Ponts et Chaussées*, No. 54, 1885), which he quotes, for he states: "The tube was proposed by Pitot, Geometer and Engineer, in 1732, to gage the river streams; this instrument was perfected by Darcy, who added to it, in 1856, the straight tube to indicate the static pressure."

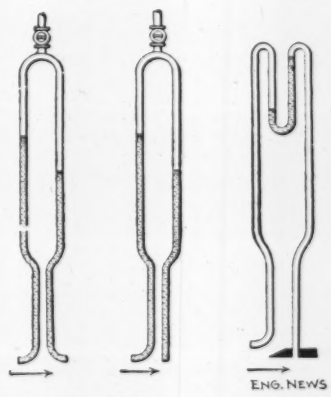

FIG. 2. FIG. 3. FIG. 4.

According to some, the trouble with the original Pitot tube had been with the flaring opening of the bent tube, and according to others, the double-tube instrument became really perfect only when the straight tube was provided with a thin guide-plate flush with the plane of the opening, as shown in Fig. 4.

2. As to *C*. Dubuat observed that plates moving with a given velocity in a large body of still water encountered less resistance than when immersed in a mass of water moving at the given velocity. This fact, ascertained through repeated observation, became known as the paradox of Dubuat, and it naturally gave rise to numberless discussions. The question is settled now, thanks to

the efforts of distinguished engineers, such as Bazin, Boussinesq, and particularly Prof. Rateau, who, in the paper before referred to, recounted the most conclusive experiments that perhaps could be devised to clear the subject. We know now that the variation of resistance observed by Dubuat was caused by the uneven velocity throughout the moving mass of water.

In the case of Mr. Airey, he had no difficulty in finding the coefficient of correction "K" in the formula $h = K\frac{v^2}{2g}$ because he made the tests with the different forms of Pitot tube by moving each tube at a constant velocity through a considerable mass of water in a state of rest. It would have been very difficult, if not impossible, to produce a moving stream of sufficient size to approximate the relative proportions of the instrument to the mass of water dealt with per unit of time and furthermore to impart throughout such a mass the required uniform velocity. Had Mr. Airey experimented with an ordinary stream, or with a pipe of large size, his results would have proven quite different. It was such considerations as these that prompted investigators to disregard Pitot's axiomatic theory and to try to explain the performance of the tube by the theory of impact, which gave $h = K'\frac{v^2}{g}$, where K' is an appropriate experimental coefficient. But most investigators, like Mr. Airey, knowing that $h = \frac{v^2}{2g}$ for perfect conditions, have sought to establish some kind of theory that would suit the answer to the problem set before them.

With but a little stretching of the imagination it is easy to prove that the theory of impact suits the Pitot tube, provided the same assumption is used which Mr. Airey so conveniently provided to suit his own theory. Mr. Airey assumes that a cone of "dead" water is formed in front of the opening of the tube and that this cone, Fig. 5, co-axial with the tube, acts as a wedge to divide the current, the stream lines of which adjust themselves around the cone and re-form finally past the bend of the tube. Now the impact theory was first applied upon the supposition that a jet of water of cross-sectional area equal to that of the tube impinged upon the plane of the opening and was deviated at right angle to the direction of the jet, whence $h = \frac{v^2}{g}$, and the necessity of a corrective coefficient to agree with observed fact. Assuming now that a cone of "dead" water is maintained ahead of the opening, and applying the formula applicable to this case, as given by Weisbach, "Mechanics of Engineering," p. 1010, viz., $P = (1 - \cos\alpha)\frac{r}{g}Q\gamma$ where P is the total impact pressure in lb.; Q is the quantity of water flowing per second; $\alpha = \frac{1}{2}$ the apex angle of the cone, and γ is the specific gravity of water. Let ω be the cross-sectional area of tube, and h be the velocity head, then $P = h\,\omega\gamma$, and $Q = \omega r$, whence we obtain by simplification $h = (1 - \cos\alpha)\frac{r^2}{g}$. The apex angle which would make $(1 - \cos\alpha) = \frac{1}{2}$ is evidently $60° \times 2 = 120°$, since $\cos 60° = 0.5$.

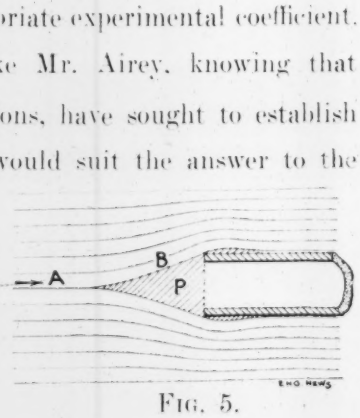

FIG. 5.

(Reproduced from Fig. 2 of Mr. Airey's article, Apr. 17, 1913, p. 782.)

It is thus seen that with a little complaisance the impact theory can be made to agree with the facts very nicely. The 120° angle is certainly not out of reason, and after going so far we might as well agree that the generatrix of the cone could be a sinusoid, in which case the impact formula would still apply in a general manner, the main point being to determine the exact shape of the generatrix.

3. As to D. It is logical to assume that the mouth of the tube is capped with a body of "dead" water forming a sort of wedge, by means of which the current is deviated. The streams follow in lines of least resistance from the apex of the wedge to the end of the tube bend. The great difficulty is to ascertain the contour of the wedge; if we may judge from the photographs of projectiles in transit we may safely assume that the cap, instead of being like a sharp-pointed cone, is most probably a paraboloid, its size depending, of course, upon the velocity of the stream relative to the tube. One thing is certain, the tube has to displace a volume of water equal to the product of the cross-sectional area of the tube by the velocity of the current; but, as usually that cross-section is very small, as compared to that of the flowing mass, it is probable that the disturbance caused by the tube is local, that is, it affects only the region immediately surrounding it, the water flowing therethrough with increased velocity.

It has been assumed that the cap is composed of "dead" water; that should be understood to mean that the water thus located does not flow with the streams surrounding it, but not that it is in a quiescent state, for it is probably a most tumultuous mass of whirls. We have thus to deal with three uncertainties, viz., the existence of the cap, its shape and its composition. It seems probable that with proper means of investigation these points can be cleared, but, until they are, it is perhaps idle to seek to establish a purely mathematical theory of the Pitot tube.

It seems likely that at the apex of the cap of "dead" water there is an impact effect, while along the generatrix there is a deviating effect. Whatever form the generatrix of the cap may have, the problem requires the study of the transformation of the stream from A to B, Fig. 5. At A the cross-section may be assumed as $\lrcorner w = \lrcorner h \times \lrcorner b$, but while the area $\lrcorner w$ may be kept constant, the width $\lrcorner b$ will go on increasing from the apex to the base, while the height $\lrcorner h$ will correspondingly decrease. Such changes may be accompanied by changes of pressure and velocity. So much for one elementary stream. But the next stream is also affected by the changes in the first, and, being differently located, its deformation is somewhat different from that of the first; then all the other streams extending from the generatrix of the cone to what might be termed the normal or unaffected streams must be deformed to some extent. The pressure exerted at the given point B on the generatrix of the cone must then be the resultant of all the elementary forces effecting the deviation of all the streams

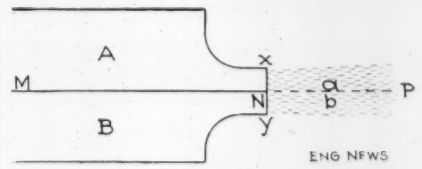

FIG. 6.

cut by a normal to the generatrix at the point B. These considerations prove that the subject is fit only for the mathematician well posted on the theory of molecular mechanics.

4. As to E. Mr. Airey attempts to solve a mystery by means of another mystery, but of a lesser order than the first, and that is hardly compatible with expectations. To quote him, p. 782: "Assuming that smooth motion exists, i.e., no discontinuity of flows occurs, or, more definitely, the velocity of any streamline cannot be more than infinitesimally different from the velocity of a streamline infinitesimally distant from it, then it follows that the boundary of "dead" water must be a streamline of infinitesimal motion." He then proceeds to consider two points A and B of the same streamline, Fig. 5 (Fig. 2 of Mr. Airey's paper), and writes the Bernouilli equation thus:

$$\text{Point } A \qquad\qquad \text{Point } B$$

$$\frac{v_A^2}{2g} + h_1 + \textit{atmos. press.} = \frac{v_B^2}{2g} + \frac{p}{w} + \textit{atmos. press.}$$

v_A, v_B = Velocity at A and B respectively;
h_1 = Depth of point A below the surface;
p = Pressure in *dead* water, constant in a horizontal plane;
W = Specific gravity of water.

Then if h is the height of water in the tube above surface level and a is the cross-sectional area of pipe: $pa = (h_1 + h)Wa$. Now, since v_A is the velocity of the stream and v_B is infinitely small, therefore negligible, $\frac{v_1^2}{2g} + h_1 = \frac{p}{w} = h_1 + h$ and finally $h = \frac{v^2}{2g}$.

Instead of assuming a conical cap of dead water, it would be just as fair to assume the cap as made of metal and composed of two parts, one conical connected to another of cylindrical form, which would fit exactly the bore of the tube like a frictionless piston. In both cases the body of "dead" water and the metal cone are assumed to be solid; then what becomes of the stream considered, which had a high velocity v_A at point A just before engaging the cone and then, midway up the cone, at point B, found its velocity v_B so small as to be negligible? According to Mr. Airey's premises, the current would be practically stopped along the generatrix of the cone and, as the difference in velocity between adjacent streamlines would be infinitesimal, it would require a goodly number of streams, piled up one against the other, to reach a sufficient distance from the generatrix where to find again the normal velocity of the current as observed at point A. This means that the cone would be practically surrounded by space where high pressure would obtain, which is totally disproved by numberless actual tests made with juxtaposed static and velocity pressure tubes, such as are used to measure the flow of liquids and of gases. It would appear as if Mr. Airey strained a point, and that consequently the theory he advanced is not acceptable.

5. Mr. Airey states, p. 783: (c) The greater the disturbance to streamline motion, the greater the discrepancy between the experimental head and $\frac{v^2}{2g}$, h always being less than $\frac{v^2}{2g}$. This is totally disproved by the experiments Prof. Rateau made and described in the paper referred to. He used a large box AB, Fig. 6, divided longitudinally by a thin partition Mn, and he caused to be maintained in each compartment so formed a uniform pressure by means of a fan blower. Means were provided to vary at will each pressure, so as to obtain any desired difference of pressure between the two compartments, and consequently different velocities of the issuing streams a and b. With a Pitot tube placed in either of the currents, close to the mouth xy of the nozzle, the height of the column of water observed was precisely equal to that read on a pressure tube attached to the corresponding compartment. But when the Pitot tube was made to oscillate by means of an ingenious pendulum device, such that the tube remained in one current as long as in the other, the time of oscillation being adjustable at will, it was found that the reading of the tube was greater than would be produced in the high pressure, or high-velocity current. Mr. Rateau shows that the coeffiicient (K) in the formula $h = K\frac{v^2}{2g}$ where V is the true mean velocity, may vary from 1 to 1.15, when the ratio of velocities does not exceed 2, but that with further increase of this ratio the coefficient increases rapidly, until it reaches the ultimate value 2. He concludes that the Pitot tube is an instrument which measures, not the mean velocity of a stream, but rather, the mean of the square of the velocities, that is, the mean momentum of a stream.

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An Improved Quartz-Tube Mercury-Vapor Arc Lamp has been designed for American uses by the General Electric Co. under the direction of E. Weintraub, of Lynn, Mass. This presents several features of departure from the German type described in "Engineering News," Dec. 5, 1907. Previously there had been difficulty in sealing the metal electrodes into the quartz tube on account of the difference of expansion and on this account ground joints had been resorted to. Now rolled tungsten is used, reducing the difference in coefficient of expansion somewhat but yet not enough to produce a satisfactory terminal: the improvement has been completed, however, by the development of a glass which adheres to the tungsten and has the same coefficient of expansion as it, and graduates into the pure quartz of the tube. This is a somewhat cheaper terminal than that previously used and allows tripling the current density in it.

The older lamp had both electrodes of mercury; with the mercury anode an extra amount of vapor had to be condensed at the cathode chamber and this required some adequate means of heat dissipation. Sufficient vapor comes from the mercury cathode alone and with the anode of solid material the construction of the lamp is simplified by removing the need of special heat dissipators. By certain precautions, tungsten becomes available for use as a solid anode.

The standard tube unit at present developed is for 4-amp. lamps with 80 volts across the tube. This is somewhat over 5 in. long with a luminous length of 3½ in. For use on 110 volts, direct current, the following figures are reported: watts consumed by the lamp, including mechanism, 440; mean spherical candlepower, 630; watts per mean spherical candlepower, 0.7. A 220-volt direct-current multiple-service lamp has been made with a 9-in. tube, 7 in. luminous length, and with 170 volts across the arc with 4 amp. Such a lamp would require 880 watts across the lamp and mechanism, would have a mean spherical candlepower of 1600 and show 0.55 watt per mean spherical candlepower. A lamp has been developed for alternating-current circuits and this has three electrodes disposed after the fashion of the mercury-vapor rectifier. The efficiency of such an arrangement is somewhat higher than the direct-current lamp (including the mechanism), on account of a smaller loss in the lamp transformer than in the resistance of the direct-current type. (See "Eng. News," Sept. 12, 1907.)

The quartz-tube lamp can be arranged for series circuits and the efficiency rises here with the elimination of the resistance used to steady the current. A 700-watt lamp on a series circuit would show a specific power consumption of 0.35 watt per mean spherical candlepower.

Sewage Treatment Works for Fitchburg, Mass.

By Frank A. Marston*

SYNOPSIS—Sewage-treatment works, consisting of Imhoff tanks, sludge beds, sprinkling filters and secondary or final settling tanks are about to be built for Fitchburg, Mass., under a contract awarded in May, 1913. Special features of this plant are rectangular Imhoff tanks, built side by side with dividing walls, cement-plaster partitions forming troughs and gas vents, and the use of structural-steel frames to support the reinforced-concrete walls of the tanks and also the partitions just mentioned; the installation of the air lift for removing sludge from the Imhoff tanks; the approval by the Massachusetts State Board of Health of sprinkling filters, the first plant of the kind to be thus approved; the construction of sprinkling filters 10 ft. in depth; the building of a 2-in. cement plastered curtain wall between the natural ground and the stone filling of the sprinkling filters.

The City of Fitchburg is located in the north central part of the State of Massachusetts on the North Branch of the Nashua River. In 1910 the city had a population of 37,826. A large number of manufacturing industries are located here on account of the excellent water power afforded by the numerous storage reservoirs along the river. The city is fairly well served by a system of sewers designed on the combined plan, which empty into the river at various points along its course. During the last two years, an intercepting sewer has been under construction, and at the present time is nearly completed, varying in size from 48 to 30 in. in diameter. The intercepting sewer will divert the sewage from the river and convey it to the trunk sewer through which it will flow to the sewage-treatment works. For a distance of 5500 ft. above the sewage-treatment works, the trunk sewer is in the form of an inverted siphon, constructed of 30-in. cast-iron pipe, at the upper end of which a chamber has been constructed with an overflow direct to the Nashua River, and a 36-in. stub for the future construction of an additional inverted siphon to be built when the normal quantity of sewage exceeds the capacity of the present siphon. Before the sewage enters the inverted siphon, it will pass through a grit chamber and coarse screen, where the gravel and sand will be removed and large objects, which might cause obstruction to the inverted siphon, will be retained. This grit chamber has been constructed in the sewer department yard where it will be readily accessible for inspection and cleaning.

In making studies for the future, the rate of growth of the city of Fitchburg was compared with that of other cities of a similar size and after taking into account all the various conditions an increase of 15% in population each five years was assumed to be the probable rate of growth to be expected. On this basis, the population to be expected in 1925 will be 57,400 and in 1940, 87,200.

The intercepting sewer was designed to provide for a maximum rate of sewage flow from the residential districts of 150 gal. per capita per day; a maximum ground water leakage of 1960 gal. per acre per day, approximately equivalent to 74,000 gal. per day per mile of sewers; and an allowance for industrial wastes of 8000 gal. per day per acre of industrial or mercantile districts. The ultimate maximum rate of flow to be provided for by the intercepting sewer, on the above basis, will be 39,000,000 gal. per day, which, based on the population to be expected in the year 1940, will be at the rate of 450 gal. per capita per day. No special allowance was made for storm water as it is the intention at some time to separate the storm water and sewage. In the meantime, storm water will be admitted up to the full capacity of the intercepting and trunk sewers, the amount being controlled by automatic sewer regulators with overflows to the river. The quantity to be carried by the trunk sewer in times of storm will be regulated by the overflow weir in the siphon chamber.

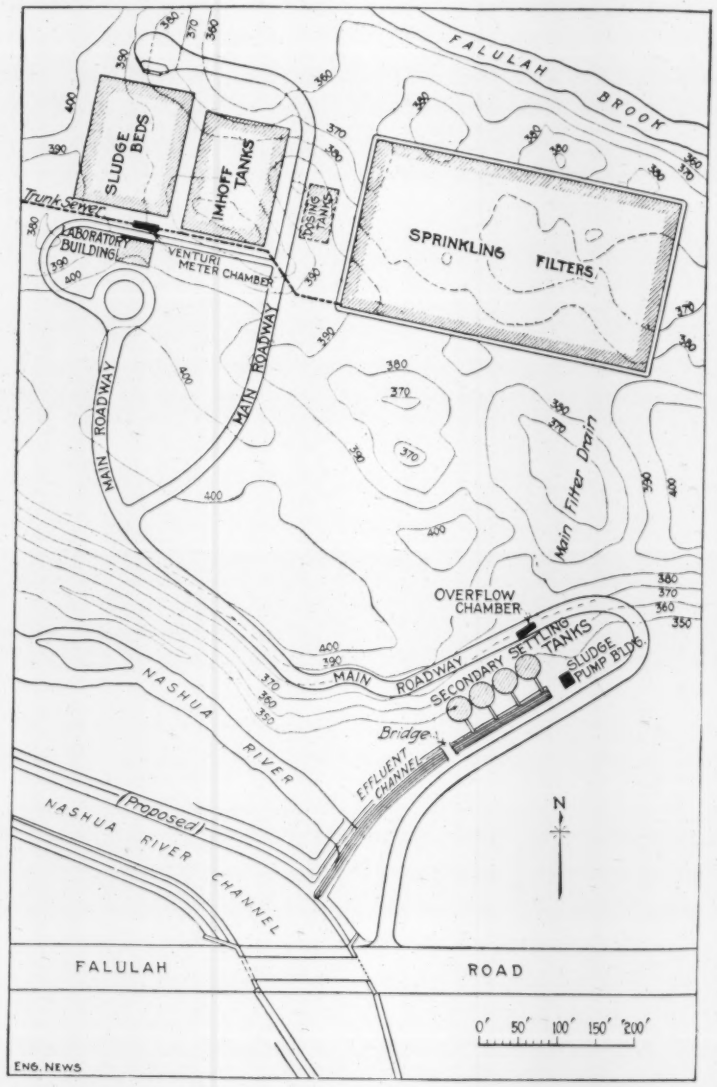

Fig. 1. General Layout of Sewage Works, Fitchburg, Mass.

In 1910, the normal water consumption was approximately 100 gal. per capita per day, and from careful studies and sewage measurements, it was determined that the normal quantity of sewage to be expected would be about the same. The design of the sewage-treatment works was based, accordingly, on a normal quantity of sewage of 100 gal. per capita per day. Certain portions of the plant, such as conduits and pipe lines, were designed to carry the maximum capacity of the trunk sewer;

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the tanks and sludge beds were designed to provide for the sewage of 55,000 persons; and the sprinkling filters for the sewage of 40,000 persons. When the sewage-treatment works are completed it is expected that the normal sewage flow will be about 4,000,000 gal. per day with a maximum rate of flow of 140% of the normal and a minimum rate of flow of 70% of the normal. The area would have to be made on account of the rapid growth of the city. From the studies made it seemed probable that a satisfactory effluent could be obtained from sprinkling filters followed by secondary sedimentation, at less cost.

The plant, as designed, consists essentially of Imhoff settling tanks with sludge beds, sprinkling filters and

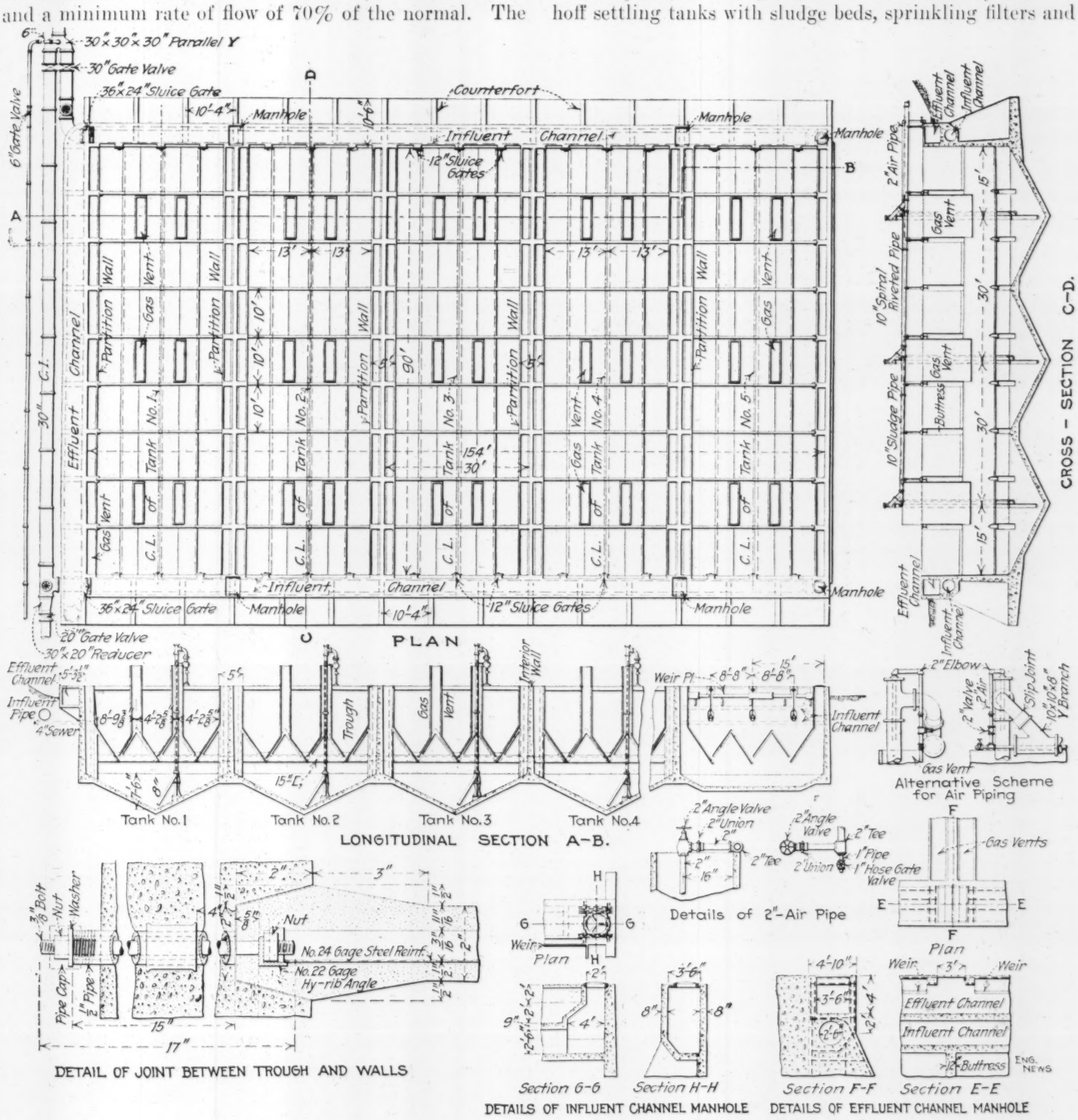


FIG. 2. DETAILS OF IMHOFF TANKS, FITCHBURG SEWAGE WORKS

maximum storm-water flow to be delivered at the sewage-treatment works will be approximately 12,000,000 gal. per day.

SEWAGE-TREATMENT WORKS

Although it was recognized that in all probability no better effluent could be obtained than that produced by intermittent sand filters properly constructed and operated, it was deemed inadvisable to construct this type of plant, owing, principally, to the large area required for present needs and the fact that frequent additions to this secondary settling tanks (see Fig. 1 for general layout). The tract of land selected for the sewage-treatment works lies partly in the southeasterly portion of the city of Fitchburg and largely in that portion of the town of Lunenburg adjoining. It is about 800 ft. from the nearest dwellings, and the prevailing wind is in the direction away from the city. The chief disadvantage of the location is the large quantity of earth excavation required in order to build the works at a suitable elevation to avoid pumping the sewage.

The use of sprinkling filters in Massachusetts in the

past has been limited to small experimental beds operated at the several experiment stations. The approval by the Massachusetts State Board of Health of this type of plant for Fitchburg marks an advance in the history of sewage treatment in the state, although, in this case, the approval provides for the possible use of intermittent sand filters operated at a high rate to further treat the sprinkling-filter effluent if it should prove necessary.

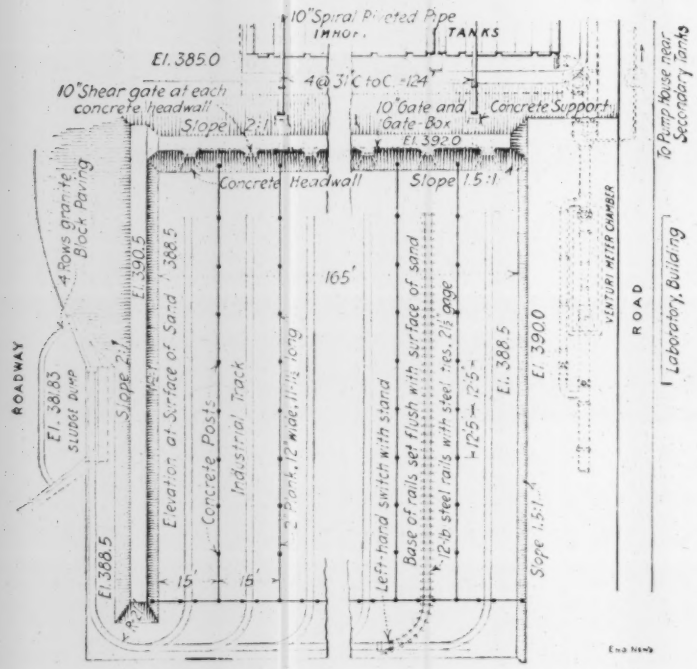


FIG. 3. SLUDGE BEDS, FITCHBURG SEWAGE WORKS

MEASURING APPARATUS—The quantity of sewage delivered at the works will be measured by a 30-in. by 15-in. Venturi meter with 12-in. float chambers and 7-in. copper floats, operating a type-M Register-Indicator-Recorder, furnished by the Builders Iron Foundry, of Providence, R. I. The meter will be equipped with vent cleaners and hand-hole openings on both the upstream and throat pressure chambers, and will be set in a concrete chamber below the surface of the ground. The recording instrument will be located near-by in the office on the second floor of the laboratory building.

IMHOFF TANKS—Five Imhoff tanks (Fig. 2), each approximately 90 ft. long and 30 ft. wide, were designed to provide for three hours' storage for 125% of the normal flow of sewage (100 gal. per capita per day), for a population of 55,000 people. The tanks are rectangular in shape with a vertical wall 18 ft. 5 in. in depth, below which the bottoms of the tanks are constructed in the form of inverted pyramids, 7 ft. 6 in. deep, three pyramids to each tank, making a maximum depth of 25 ft. 11 in. below the top. Each tank is divided into two compartments, the upper one for sedimentation and the lower one for sludge storage, by means of cement-plaster partition walls, forming three troughs running longitudinally through the tanks. At the bottom of each trough is a slot 6 in. wide through which the solids will settle into the sludge compartment below. The sludge compartment was designed to retain sludge for a period of 6 months, on the basis of 0.007 cu.ft. of sludge being produced per capita per day. Six central gas vents, 24 in. wide by 9 ft. long, and side gas vents, 24 in. wide, continuous along the side walls of each tank, are provided.

The sewage will be delivered to the Imhoff tanks through 30-in. concrete conduits built in the end walls of the tanks from which the sewage will pass into each tank through three 12-in. openings controlled by sluice gates. Provision has been made for reversing the direction of flow into the tanks in order to make the sludge deposit more uniform. The effluent will flow over weirs, running practically for the full width of the tanks, into concrete conduits built in the end walls above the influent conduits. It is estimated that the maximum velocity of the sewage entering the tanks will not be greater than 2 ft. per sec., and when the rate of sewage flow exceeds the normal by 125%, amounting to 6,875,000 gal. per day, the horizontal velocity of flow through the tanks will be approximately 25 ft. per hour.

The tank walls will be constructed of reinforced concrete supported by structural-steel frames, which not only provide the main support for the exterior walls, but also for the thin partition walls between the sedimentation compartments and the sludge compartments. These thin partition walls will be constructed of three-coat cement plaster on rib-metal reinforcing lath, securely fastened to the structural-steel frames. There are eight frames to each tank, spaced 10 ft. c. to c. A special form of joint, shown as a part of Fig. 2, was designed to anchor the rib-metal reinforcing lath to the tank walls during construction, and at the same time allow for the expansion and contraction of the completed work. In building the end walls of the tanks, pieces of wrought-iron pipe will be set in the forms through which bolts will be placed to anchor the rib-metal reinforcing lath to the wall, and a groove will be left in the concrete wall

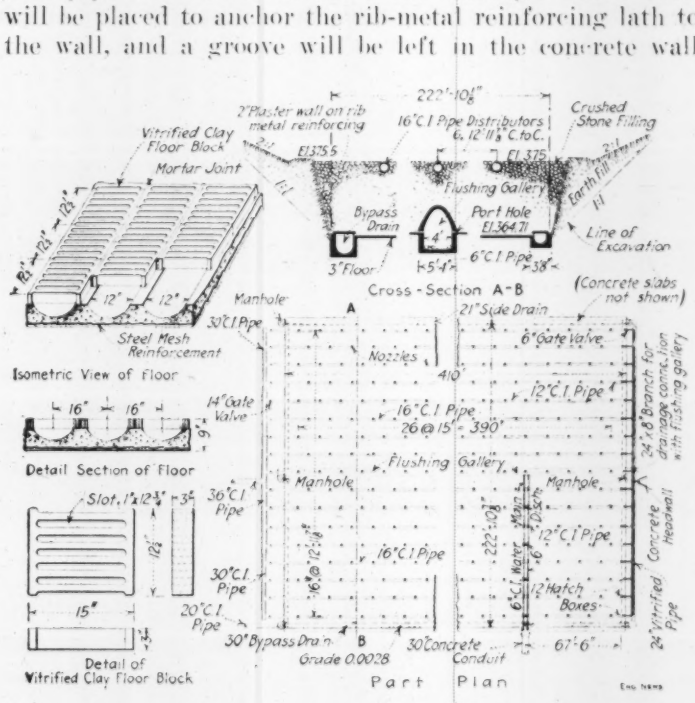


FIG. 4. SPRINKLING FILTERS, FITCHBURG SEWAGE WORKS

along the line of the joint and later filled with cement plaster to form a gas cutoff between the sedimentation and sludge compartments. After the thin partition walls have been completed, the bolts will be removed, thereby releasing the anchor on the rib-metal lath and allowing the thin partitions to expand and contract more freely.

SLUDGE BED AND AIR LIFT—Owing to the topography of the land on which the sewage-treatment works will be built, it was found desirable to construct the sludge beds

at a higher elevation than the Imhoff tanks, thereby making it necessary to pump the sludge. The usual forms of pumping machinery are not suitable on account of the breaking up of the sludge and the resulting loss in gas content, which would be disastrous to the rapid drying qualities for which Imhoff sludge is noted, and on this account use was made of the "air lift" principle. An 8-in. cast-iron pipe will be erected in the center of each pyramidal hopper extending from the bottom of the hopper to the top of the tank (Fig. 2). A 2-in. air pipe will deliver compressed air at a point in the 8-in. pipe about 17 ft. below the normal water line. This compressed air will rise in piston-like masses, carrying with it quantities of sludge. The initial lift will be about 8½ ft. from the normal water line to the top of the vertical pipes, from which the sludge will flow by gravity to the sludge beds through 10-in. riveted steel pipes, into a 10-in. cast-iron header on which are located the sludge outlets controlled by 10-in. shear gates.

The sludge-drying area (Fig. 3) was divided into eleven beds each 15 ft. wide and 111 ft. long, separated by small partitions constructed of 2-in. creosoted planks 12 in. wide, set on edge in concrete posts, spaced about 12 ft. c. to c. Each bed will be served by a narrow-gage track laid along the center line with the ties flush with the surface of the sand. The total area of the sludge-drying beds is approximately 18,300 sq.ft., being based on three persons per square foot of area for a population of 55,000 people. The sludge will be run onto the beds to a depth of about 8 in., but the partitions are 12 in. high. No underdrains will be constructed at the present time owing to the excellent drainage qualities of the soil, although it is intended to construct underdrains, if, in the future, they should be found necessary. After the sludge has dried sufficiently, it will be shoveled into small tip cars, which will be hauled to the northerly side of the sludge beds where the sludge will be dumped from the top of a concrete retaining wall directly into wagons driven alongside the wall at a lower elevation. It is planned to dispose of the dry sludge by filling low land belonging to the city.

SPRINKLING FILTERS—The sewage after leaving the Imhoff tanks will flow alternately into one or the other of two dosing tanks of approximately 36,000 gal. capacity each where it will be stored until automatically discharged through 30-in. cast-iron siphons into the main distributors of the sprinkling filters.

The area of sprinkling filters required was based on the assumption that one acre of stone 10 ft. deep will care for the sewage from 20,000 persons. The beds now under construction will have an area of 2.07 acres at the floor level. The area is rectangular in shape (Fig. 4), 405 ft. long by 222 ft. 10 in. wide at the floor level and 5 ft. longer in each direction at the top. The crushed stone, a local granite, from 1 in. to 2 in. in size, will have a depth of from 10 ft. to 10 ft. 6 in. above the false-floor system. The surface area of the filters was increased to allow for the overlap from the adjacent row of nozzles.

The sewage will be conveyed to the filters through 36-in. and 30-in. cast-iron main distributors, from which 17 lateral distributors, 16 in. and 12 in. in diameter, will run the full length of the beds. These cast-iron distributors will be set in the stone just below the surface and the nozzles will be fastened directly to the distributors, thereby climating long riser pipes. The nozzles are located at the apices of equilateral triangles 15 ft. on a side. At the lower end of each lateral distributor there will be a 6-in. blowoff with an outlet to the low area on the east side of the sprinkling filters, which will act as a small sand filter for the sewage blown out of the distribution system or for the sewage drained from any portion of the distribution system which may be cut out for repairs or during cold weather to prevent freezing. Hatch boxes will be located at each end of each lateral distributor, as well as in the center where the size changes from 16 to 12 in. in diameter. By these means the distribution system can be readily cleaned or examined at any time and the filters can be operated in 17 units.

The crushed stone will rest on a false-floor system of the type shown in Fig. 4. The concrete floor will be formed into a series of channels or corrugations, spaced

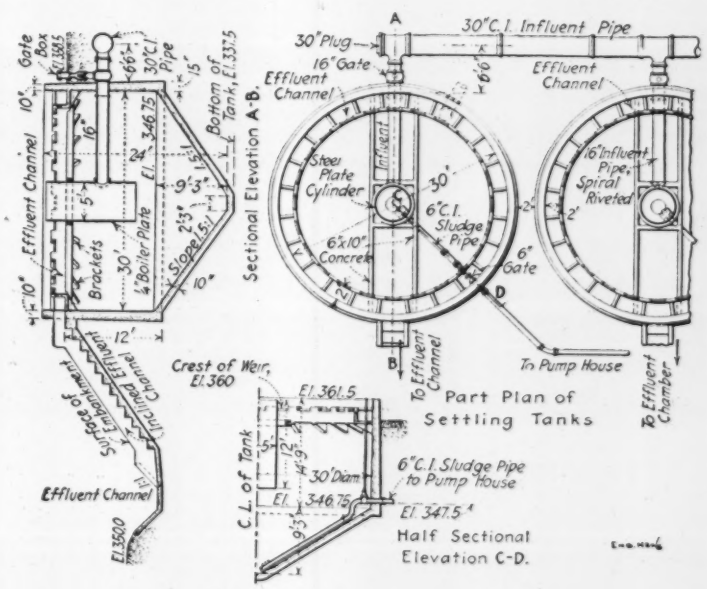


FIG. 5. SECONDARY SETTLING TANKS, FITCHBURG SEWAGE WORKS

16 in. c. to c., and laid on a slope of 1 in 222, draining from the center line of the filters in either direction toward the outer edges. The concrete channels are covered by vitrified clay blocks, slotted to obtain a large amount of drainage area. The upper ends of the channels extend into a flushing gallery, 6 ft. high by 4 ft. wide, at a distance of 2 ft. 6 in. above the floor of the gallery, thereby making it possible to examine each of the floor drains and also flush or clean them in case solid matter should be deposited therein. A cast-iron water main with hose outlets will be laid in the gallery for convenience in flushing.

The sprinkling filters are almost entirely constructed in excavation with the surface of the filters below the natural ground level. The floor channels drain into U-shaped concrete underdrains (built along the edge of the filters on the north and south sides), covered with concrete slabs, and which lead to a main collector drain through which the effluent flows from the sprinkling filters to the settling tanks. Manholes are located so as to provide access to the underdrains as well as to furnish ventilation. No retaining wall will be built around the outside edges of the filters but a thin partition wall, constructed of cement plaster on rib-metal lath, will be built to separate the crushed stone from the earth fill-

ing. This partition wall was not designed to carry any unbalanced pressure as it was intended that the earth backing and the crushed-stone filling should be placed simultaneously and thereby avoid injury to the wall.

The filter effluent conduit will be constructed of reinforced concrete, 30 in. in internal diameter for a portion of the distance and the remainder will be constructed of 30-in. cast-iron pipe. At the lower end of the conduit, near the secondary settling tanks, a small overflow chamber will be constructed containing a weir 25 ft. long built at such an elevation as to make it impossible for anyone, either willfully or through carelessness, to shut the influent gates in the secondary tanks and back the sewage up into the sprinkling filters or to block the outlets of the secondary tanks and cause them to overflow.

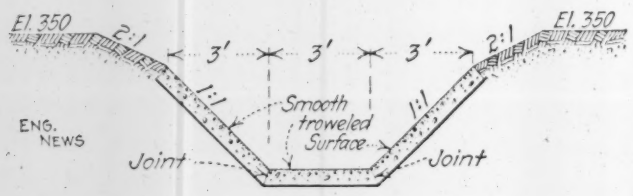


FIG. 6. CROSS-SECTION OF FINAL EFFLUENT OUTLET, FITCHBURG SEWAGE WORKS

The overflow chamber also includes a means for bypassing the filter effluent around the tanks.

SECONDARY SETTLING TANKS—The secondary settling tanks, four in number (Fig. 5), constructed of reinforced concrete, are cylindrical in shape with conical hopper bottoms. The tanks are 30 ft. in internal diameter, 14 ft. 9 in. deep in the cylindrical portion and 9 ft. 3 in. deep in the conical bottom, making a total depth of 24 ft. The tanks were designed on the basis of a sedimentation period of one hour for 125% of the normal daily flow of sewage from a population of 55,000 persons. The sewage will enter each tank from the 30-in. cast-iron filter effluent conduit through a 16-in. spiral-riveted steel pipe to a cylindrical pipe 5 ft. in diameter, constructed of ¼-in. steel boiler plate, 12 ft. long, set vertically with the top 1 ft. 2 in. above the flow line of the tank, which will cause the inflowing sewage to pass downward and underneath the lower edge.

It also serves to retain floating matters and prevent them from passing out with the effluent. The sewage will flow vertically upward through the tanks with an average velocity of approximately 15 ft. per hr. The effluent channel is located around the circumference on the inside of each tank and contains 24 weirs 2 ft. long, over which the effluent will flow into the effluent channel, thence down a flight of concrete steps to the main effluent channel and finally to the Nashua River.

The secondary settling tanks will be cleaned frequently by pumping out the entire contents of a tank, including sludge and water, with a 5-in. motor-driven, centrifugal pump, located in a small building near the tanks, and forcing it through a 6-in. cast-iron force main up into the influent conduit to the Imhoff tanks, in which the sludge will be deposited and allowed to decompose, together with the sludge from the crude sewage. This method of operation avoids the necessity of building separate sludge beds for the secondary settling tank sludge, which are usually troublesome because the sludge dries slowly and is apt to give off disagreeable odor, due to the large number of worms which it contains. When mixed with the crude sewage sludge in the Imhoff tanks, the secondary tank sludge will go through the "rotting out" process, the worms will be decomposed and the resulting sludge will be free from nauseating odors and will dry out much more readily.

FINAL EFFLUENT CHANNEL—The main effluent channel from the secondary settling tanks to the Nashua River is trapezoidal in section, 3 ft. in depth, with a bottom width of 3 ft., and sides built on a slope of 1 to 1 (Fig. 6). Both the sides and bottom will be paved with concrete.

In addition to the work already described, a considerable amount of excavation will be involved in improving and straightening the Nashua River channel, and in the construction of about one-half mile of macadam road to various portions of the sewage-treatment works.

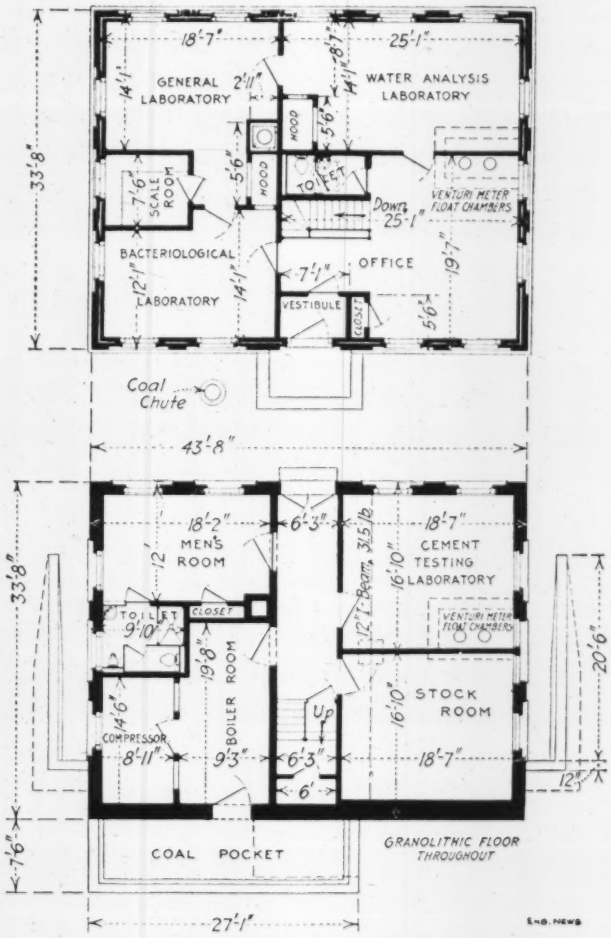


FIG. 7. FLOOR PLANS OF LABORATORY, FITCHBURG SEWAGE WORKS

LABORATORY—The laboratory building will be a two-story structure, 33 ft. 8 in. by 43 ft. 8 in. in plan, of grey, rough-cut brick, with a red tile roof and limestone trimmings. Complete equipment will be installed for general chemical, water analysis, bacteriological and cement-testing laboratories (see Fig. 7 for floor plans). The air compressor for furnishing compressed air to be used in pumping the sludge in the Imhoff tanks will also be installed in this building.

The sludge-pump building, 14 ft. by 17 ft. in plan, will be of a similar type of construction, one story high.

The project is under the general direction of the Sewage Disposal Commission, a board of three men appointed by the Mayor, and created by an act of the Massachusetts

Legislature in 1910. This board, of which Arthur H. Lowe is chairman, has under its charge not only the construction of the intercepting sewer and sewage-treatment works, but also the maintenance of the sewerage system together with the making of sewer extensions and house connections. David A. Hartwell is chief engineer and Harrison P. Eddy is consulting engineer. The plans and specifications for the sewage-treatment works were prepared in conjunction with Mr. Hartwell at the office of Metcalf & Eddy, consulting civil engineers, Boston, Mass. Proposals for the construction work were received May 15, and the contract has been awarded to the lowest bidders, R. H. Newell Co., and N. S. Brock, of Uxbridge, Mass. The contract will amount to approximately $215,000.

A Grouting Process for Preventing Slides on the Panama Canal*

By Geo. S. Rice†

In the Culebra Cut on the Panama Canal serious difficulties are being experienced from slides, and the Isthmian Canal Commission's report for 1912 contains an interesting description of the geological formation and the cause of slides, by the geologist, Mr. McDonald.‡

The writer has reached the conclusion that the slides may continue to be a serious matter. Therefore it will be advisable to give consideration to any methods which will tend to prevent slides. A process used in shaft sinking and tunnel work suggests a method of erecting an underground retaining wall which (though not feasible for ground actually moving) will perhaps prevent the formation of a slide by taking care of the unbalanced pressures due to deep excavation.

CEMENTATION PROCESS FOR SINKING SHAFTS

While the method of filling cavities and rock crevices behind tunnel lining with cement grout has long been employed, a special application called the cementation process has been highly developed in France for sinking through porous and creviced water-bearing strata. Briefly, it consists of drilling a series of holes surrounding the shaft location through the porous strata to the more or less impervious coal measures, and pumping in cement grout under high pressure. The pumping may be either continuous, as the drilling proceeds, or (as in later undertakings was found to be better) in stages at intervals alternating with drilling every 16 ft. By this method a cylinder of cemented material is constructed within which the shaft can be sunk. In the earlier undertakings four drill holes were used, but for later shaft sinkings six holes were employed in a circle of 24 ft. diameter.

To prevent leakage to the surface of the injected grouting a pit is first dug for each bore-hole through the loose earth and concrete placed tightly about a 12-in. standpipe, the top of which is capped. The cap has a stuffing-box, through which passes a grouting pipe that can be pushed to near the bottom of the hole. The pipe is connected with the pump, and the latter with the cement mixer. Before injection of cement begins, clear water is pumped through.

It has been found necessary to use only the finest ground cement, and employ pressures as high as 750 lb. per sq.in. to insure the thorough permeation of the cement into the small crevices and bedding planes of the strata. The cleaning out of all mud coating on the bore-hole is also found necessary. To this end it is the practice to drill the hole below the standpipe, about 7 in. diameter, and then ream to 10 in.

The water-bearing strata consist of marls or fissured chalks which are sometimes argillaceous. They are soft enough to be bored with an auger drill turned by power. The process has been so successful that it is supplanting the freezing system for sinking through highly water-bearing strata in northern France and Belgium.

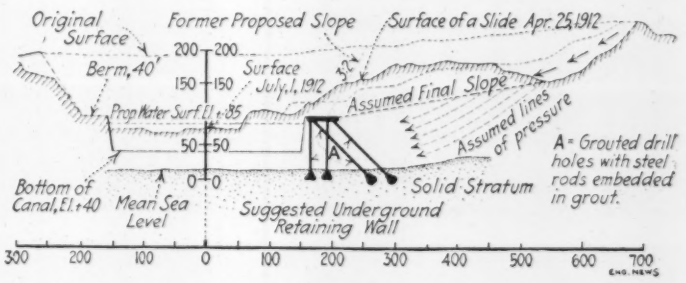
CONSTRUCTING UNDERGROUND RETAINING WALLS

The success achieved with the above process appears to offer possibilities in solidifying the slopes of unstable strata, at least sufficiently to prevent movement from occurring. The holes filled with concrete, reinforced with iron bars, would serve as deep-seated massive piles. Why not extend this principle and drill inclined holes to solid strata, and insert in them heavy reinforcing bars which, when surrounded with cement, would act as diagonals or tension members?

A further development was to "spring" the holes at the bottom by shooting with dynamite This would open up crevices, permitting a more extensive cementation, and would provide an enlargement which would furnish anchorage for the tie bars. The upper end of the tie bar is to be held by a concrete capping. Thus the combination of vertical concrete posts and inclined metal ties (going deep enough to reach solid strata), with the ground cemented between, would furnish a triangular dam, or retaining wall, which should have great strength against lateral pressure.

The nearer the holes, the more thorough would be the cementation. The only limit would be that of cost. The system, if applied extensively, would be costly. But it would only be considered where the cost of repairing damage to an engineering work by an extensive landslide would be vastly greater.

In proposing the scheme for checking, or rather preventing, slides, the writer has had three main thoughts in mind: 1, as far as possible there should be drainage; 2, there should be a subdivision of the slopes from which the slides are liable to come; 3, there should be formed an underground dam, to prevent the foot of a slope from moving, and also to keep the water of the canal from circulating through the material. It is very much more destructive to the somewhat soluble walls to have water constantly entering and leaving the crevices through wave action, than if the ground water is merely held quiescent.



Proposed Method of Preventing Slides on the Panama Canal

The scheme is as follows, and is shown by the accompanying cut:

1. To drill a series of holes along lines parallel with the axis of the canal, these holes to be both vertical and inclined, and go deep enough to reach firm strata below the level of the bottom of the canal. The depth of the holes might need to be 100 ft. or over 150 ft.

2. Cement grout to be forced into these holes under pressures of 750 to 1000 lb. per sq.in., so that the cement will penetrate all the fissures, making the mass impervious to water, and also binding the rock together.

3. Steel rods, 3 in. diameter or more, to be grouted into the holes.

4. Before the steel bars have been placed, dynamite is to be fired in the bottom of each hole to make an enlarged space in the firm stratum which the holes should reach. These will provide anchorage at the bottom. The rods will thus act as reinforcement to the cemented zone; and the rods in the inclined holes will serve as tension members of the wall. The latter rods will therefore be made much heavier than the others. The rods are to have nuts and washers or to be upset at each end. The upper ends are to be fastened in a concrete capping over the top of the "dam."

In applying this method it must be done before the ground begins to move. It cannot be applied to ground that is actually moving. Moreover, the wall must go sufficiently deep to get into solid strata. But there is nothing except cost to prevent such an underground dam from going as deep as seems desirable, or to make the holes as large or the tie rods as heavy as desired. It would be desirable to try the method beyond the present slide areas in order to determine the obstacles and necessities of the case. The work could be pushed from either edge into the slide area. Intermediate ground walls could be constructed further up the slopes, so as to lessen the weight and also to prevent water which might enter above from working down into the larger mass below. Accompanying these dams, underground horizontal drifts might in some cases be put into the slopes to drain the ground.

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*Abstract of a paper read before the Western Society of Engineers, Chicago, May 12, 1913.

†Chief Mining Engineer, U. S. Bureau of Mines, Pittsburgh, Penn.

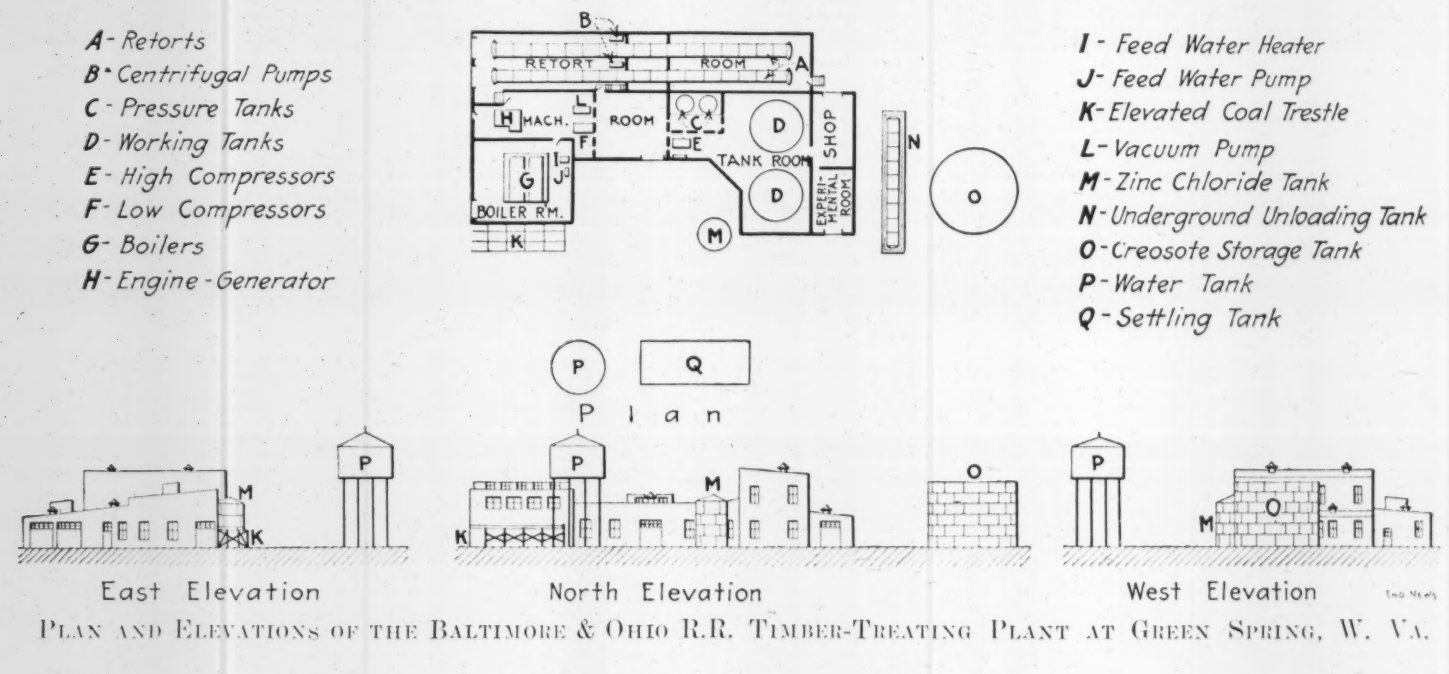
‡"Engineering News," Oct. 3 and Nov. 28, 1912.

The Timber-Treating Plant of the Baltimore & Ohio R.R.*

The Baltimore & Ohio R.R. has recently completed and put into operation, at Green Springs, W. Va., one of the most complete and modern timber-treating plants in America. It covers 60 acres and is situated close to large areas of timber land along the south branch valley of the Potomac River. The requirements of the B. & O. system approximate 2,500,000 ties annually for renewals, and a large proportion of these ties, with other timber for railroad use, will be treated in the new plant.

Practically all of the ties treated at the plant to date are oak, the number being approximately 200,000. The tanks, an underground drain tank, pressure pumps and electric centrifugal pump. Any process can be studied and pressure can be supplied as high as 300 lb. The chemical laboratory adjoins the physical laboratory, for creosote distillations, zinc-chloride analyses, etc.

The office building is of concrete and is fireproof. The same is true of the other buildings in the plant, except small hose and engine houses of wood, located some distance from the other structures. A fire-protection system has been installed and a fire department will be organized from among the employees. A 6-in. water main has been laid the entire length of the tie yard and every 300 ft. there is a hydrant. The hose house is near the office and is equipped with a reel of 300 ft.



PLAN AND ELEVATIONS OF THE BALTIMORE & OHIO R.R. TIMBER-TREATING PLANT AT GREEN SPRING, W. VA.

standard tie in use on the Baltimore and Ohio is 7x8 in. and 8½ ft. long, containing 4 cu.ft. Ties are unloaded and cribbed in piles of seven and one, and are handled by piecework. It is the intention to air-season all ties. However, if they are not received in quantities sufficient to properly air-season, the plant is designed to give a preliminary steaming and vacuum treatment before the injection of preservatives.

The location of the timber-treating plant is believed to be admirably suited for all purposes, being near large timber areas. Green Spring is at the junction of the Romney branch with the main line of the B. & O. This branch, which extends 16 miles to Romney, W. Va., with the Hampshire Southern R.R., extending 38 miles farther to Petersburg, taps a timber tract of several thousand acres, much of it being virgin forest. The outlet for all timber adjacent to the lines mentioned is by way of Green Spring, and it is merely a question of stopping the timber in transit to have it seasoned and treated.

The accompanying figure shows the plan and elevation of the works. In addition an experimental plant, consisting of a complete physical and chemical laboratory, is situated adjacent to the main building. Here is a cylinder 30 in. in diameter, 9½ ft. long, to hold three or four ties. There are also two working or pressure of hose. Water pressure for fire emergency is maintained by a high 50,000-gal. tank kept filled at all times.

There are two treating cylinders, or retorts as commonly called, 7 ft. in diameter and 132 ft. long, made of ¾-in. steel for a working pressure of 175 lb. per sq.in. Each of the retorts rests on nine concrete piers and is securely anchored to the center pier. On the remaining eight piers, the retort rests on cast-steel saddles, with nests of steel rollers between the saddles and an iron plate imbedded in the concrete, each nest having three rollers 2 in. in diameter, 10 in. long.

At each end of the retort is a door which swings on steel rollers and can be opened and closed easily by one man, notwithstanding a weight of 6400 lb. The door consists of a steel frame with flanged-steel dished head 1 in. thick. The retorts are equipped with heating coils and also with perforated pipes, used to obtain a more perfect distribution of steam when green timber is being artificially seasoned as well as for the circulating device of the Card process.

The main building is of steel-frame construction with corrugated iron sides and concrete roof. The floors of the building are of cement and there is a concrete basement so constructed that should any of the preservative be spilled it can be recovered. In the basement is a concrete sump equipped with an electric signal warning the engineer in charge when the sump is filled. The sump is emptied by means of an ejector, the liquid passing into a settling tank about 50 ft. from the building.

*From information furnished by F. J. Angier, superintendent of timber preservation, B. & O. R.R., Green Spring, W. Va.

The settling tank is also of concrete 20 ft. wide, 50 ft. long and approximately 10 ft. deep. The tank has four compartments and after the drainings from the plant enter the first section the liquid is forced to travel through each of the others in a circuitous path to the last. By this time any creosote carried from the plant falls to the bottom, because of its greater specific gravity, and enters a well in the bottom of the last compartment of the settling tank. Here an electric bilge pump forces it to an underground tank.

The boiler room, 30x40 ft., is situated adjacent to the main building, and contains two horizontal return-tube boilers of 150 hp. each, built for 125 lb. working pressure. Space is provided in the room for a third boiler to be installed when the requirements justify an enlargement. A boiler-feed heater, injector, and feed-water pump complete the equipment in the boiler room.

The oil storage tank is 40 ft. in diameter by 30 ft. high, having a total capacity of 280,000 gal. There is also a storage tank 15 ft. in diameter by 20 ft. high, for concentrated solution of zinc-chloride, with 25,000 gal. capacity. The oil-storage tank has 500 sq.ft. of heating coils in four sections. An angle stem thermometer is placed in the side of this tank (the oil being kept at a constant temperature of about 120° F.).

Near the storage tank is an underground unloading tank, 6 ft. in diameter by 60 ft. long. The tank is inclosed in a concrete pit, which will prevent waste of the creosote in the event that leakage occurs. The tank will withstand an air pressure of 50 lb. per sq.in. and creosote is forced from this tank into the storage or working tanks by air also. The working tanks and pressure tanks are all located inside the building, so that they can economically be warmed and the temperature of the working solution retained at 190°.

The working tanks are 24 ft. in diameter by 20 ft. high, each having a capacity of about 68,000 gal. They rest on concrete foundations 6 ft. above the floor line, and are equipped with three sets of cast-iron radiators with a total heating surface of 741 sq.ft. Each tank is also equipped with air coils for agitating a mixed solution of creosote and zinc chloride. Air is admitted at 100 lb. pressure and distributed in such manner as to completely mix the solution in from two to five minutes. The tanks are also equipped with mercury gages which show the true reading in cubic feet and gallons, regardless of the temperature. Each tank has a regulator to govern the steam supply and to maintain the required temperature.

The pressure tanks are 8 ft. in diameter and 14 ft. high, made of 7/8-in. steel for a working pressure of 175 lb. They are in reality a combination of pressure, measuring and drain tanks, and are located in such a way that they are readily filled while the treating cylinders are being loaded preparatory to treating a charge of timber. Compressed air can be applied through the top of these pressure tanks to force the preservative out through a bottom pipe leading to the retorts. Pressure is maintained until the required absorption is obtained in the timber, after which the valve is closed and any remaining preservative can be returned to the working tank by means of the compressed air already in the pressure tank. There is also a sufficient amount of compressed air in this tank to force all of the solution in the treating cylinder back to the working tank. The tanks are equipped with mercury indicators which show the amount of solution going into the timber.

They are also used as drain tanks to catch and measure the solution taken from the timber during the vacuum and draining process. The bottoms of the pressure tanks are only slightly lower than the treating cylinders; and though all of the drainings from the charge would not flow into the pressure tank by gravity, this is easily and quickly accomplished by admitting atmospheric pressure to the treating cylinder while the pressure tank maintains a vacuum. This combination of pressure-measuring-drain tank is unique with the plant at Green Spring. It was worked out by the writer, assisted by Card and McArdle, who were the draftsmen on pipe plans. It eliminated entirely the dirty and expensive pressure pumps commonly in use in timber-treating plants.

Recording gages and recording thermometers are connected to the treating cylinders. This places the superintendent in complete touch with the treatment in all of its details, the charts indicating the temperature, pressure and vacuum recorded for every moment the plant is in operation.

The plant is heated throughout by steam, a vacuum system being used, all condensation being returned to the boiler-feed heater and thence to the boilers. A 50-kw. generator furnishes the light for the plant and the yard, there being three arc and about 50 incandescent lamps. The electric plant also furnishes current to operate two 10-hp. 8-in. centrifugal pumps and a 1-hp. bilge pump. The centrifugals are used to circulate a mixture of creosote and zinc-chloride in the retorts while using the Card process. The bilge pump is in the settling tank and is used to pump creosote, that may have settled out from the drainings, into the underground unloading tank.

There are 130 tie cars used to deliver the ties to and from the treating cylinders. All storage-yard tracks have three rails, the outside pair being of standard gage and the inside rail fixing a 30-in. gage for the tram cars. In loading for treatment the ties are classified as hard and soft woods and as No. 1 and No. 2. For this work the men are paid at a rate per tram instead of per tie as is the case of unloading and cribbing for seasoning. Thus it makes no difference whether there are 30 or 40 ties on a tram, the cubical contents are practically the same and the amount paid is the same.

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The Pension System of the Pennsylvania R.R. has just completed its thirteenth year of operation. It will be remembered that establishment of this system was one of the early acts of A. J. Cassatt, on becoming president of the road in 1899. By it, each employee is obliged to retire, on a pension, at the age of 70, and an employee may be retired, at the age of 65, in case of physical disability. The stipend allowed amounts to 1% of the average salary, or wage, for the ten years previous to retirement, multiplied by the number of years in the service of the company. No man may enter the employ of the road after attaining the age of 45, so that anyone retiring at 70 receives at least 25% of his average annual salary for the previous ten years. This allowance is given without any obligation to the railroad and the only stipulation is that a pensioner may not re-enter the service, under any condition.

Compilation of records shows that in the 13 years, 7152 men have received $8,368,786 from the various companies. Of these men, 3345 have died, leaving 3807 on the present rolls. Of these 2843 are on the lines east of Pittsburgh and 964 on lines west. At the close of 1912, 296 of the pensioners on lines east of Pittsburgh were over 80 years and nine were over 90.

Grouting the Arches of an Old Stone Viaduct

The Paris-Bordeaux line of the Paris & Orleans Ry. crosses the valley of the Dordogne River, near Libourne, by a masonry viaduct having 100 arches of 33-ft. span. This was built in 1846-50, and during its early years longitudinal cracks appeared in the intrados of the arches, but these did not appear to be of importance until a few years ago, when they began to extend under the influence of heavier engines and rolling stock and faster trains. The most serious cracks were close to the center line of the structure. In 1900, about 100 of these cracks were noted, some of them 16 to 20 ft. long and 0.6 to 0.8 in. wide. Some repairs had been made by replacing defective stones, pointing the joints and packing the cracks with cement, but in 1909 a general system of repair was undertaken.

Three arches at a time were supported on centering and the top of the arch uncovered. The concrete covering over the masonry was not disintegrated but showed a number of longitudinal cracks which allowed water to leak through to the arch masonry. Cracks were found in the extrados of the arches, some of which penetrated (more or less obliquely) the entire thickness and connected with the cracks on the intrados. The cause seemed to be the soft character of the stone used, the edges being cracked and crushed under the influence of vibration, especially where joints were not properly filled. This action resulted in causing considerable voids in the masonry. It was necessary, therefore, to fill the voids and thoroughly bond the masonry into a solid mass, and the method adopted was to force in cement grout under pressure. As the concrete covering was mainly intact, the grouting was done from the lower side or intrados. In this way it was not necessary to interfere with the traffic, which averaged 85 trains daily.

At first a machine was used that had been employed in grouting the lining of the approach tunnels at the Orsay railway station, in Paris. This had a lower reservoir for the grout, and an upper chamber in which air was compressed by a hand-pump. This was not satisfactory. The pressure was not sufficient to force the grout into the voids, and the grout frequently set in the pipes, causing continual delay and trouble. On the advice of Mr. Suquet, Engineer of the Metropolitan Railway, of Paris, a pressure pump was used, so that the operating piston did not come in contact with the grout, but worked in pure water, transmitting pressure through a diaphragm to the grout in an adjacent chamber. The pump was driven by a gasoline engine of 1¼ hp., the whole outfit being mounted on a truck.

The working force consisted of five men; two masons and three to attend to the grouting. The masons first cleaned out the fissures, and closed them with plaster, inserting at selected points pieces of old ½-in. lead gas pipe as nozzles. The plaster was allowed to set for two days before the grouting gang did its work. The foreman supervised the work and attended to the engine. One man prepared the grout and kept it stirred. The other man handled the injection hose, which he fitted to the lead nozzles mentioned above. This man wore a mask and goggles to protect his face and eyes from the jets of grout which spouted out when the voids had been filled. In a little while, however, he became expert at determining from the pressure in the hose the probable period of injection, and shut off the flow by a valve so that there were no overflow jets. This method was very successful and gave no trouble. The only precaution necessary was to pump water through the hose occasionally in order to prevent clogging.

Each arch had at least 20 injection nozzles, and some had as many as 100. The minimum amount of cement per arch was 110 to 220 lb., for 32 arches; the maximum was in four arches which required 1540 lb. each. The average was 475 lb. per arch. The total cost was $880; this included the cement, plaster, lead and wages. Test holes drilled into the work showed that the voids had been thoroughly filled and the stones bonded together. The old cracks have not extended, and the slipping or displacement of the stones (due to their wear) has ceased.

This work was commenced in 1909 and finished in 1911. Our information respecting it is taken from an article in the February number of the *Revue Generale des Chemins de Fer*, by Mr. Adam, Engineer of Maintenance-of-way of the Paris & Orleans Ry.

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The Idaho Public-Utilities Law recently approved by the governor is patterned after other state legislation which has proved effective in the regulation of public-service corporations. There are to be three commissioners appointed by the governor for overlapping terms of six years each at salaries of $4000. The commission appoints its own secretary and is empowered to employ engineers, accountants, inspectors, etc. The attorney-general of the state is the counsellor of the commission in actions at law. The usual scope of definition is given to the term "public utilities" and it also includes specifically wharfingers, warehousemen, and distributing companies which serve the public only indirectly. Companies constructing irrigation works are specifically excepted. The law provides that all charges by a public utility, or several jointly, must be just and reasonable without preference or discrimination and that the service must be reasonable, adequate and efficient, promoting the safety, health, comfort and convenience of patrons, employees and the public generally. The commission has ample power for making investigations, inspecting property, holding hearings, examining books and records, compelling the attendance of witnesses, regulating service, fixing rates, and enforcing its orders.

The commissioners and their employees are enjoined from divulging information received from a public utility, except such as is open to public inspection or made public by order of the commission, and disobedience of this provision is made a felony.

Thirty days' notice to the commission is required before rates may be changed and the change may not be upward without their permission. It is provided that the act shall not prevent sliding scales nor the adjustment of rates in relation to dividends under the approval of the commission. Telephone and telegraph companies are instructed to handle proffered business without delay or discrimination whether the business is from companies with whose lines physical connections may have been ordered by the commission.

Street-railway, gas, electric-supply, telephone and water corporations may construct or extend their plants hereafter only by first securing a certificate of public convenience and necessity from the commission. Exception is made, however, in territory in any city or town heretofore lawfully occupied or contiguous territory not already served. Power-generating companies, moreover, may enlarge their plants without permission or develop new plants and market the output. None of the specified classes of utilities may exercise any right or privilege or obtain a franchise without first obtaining a certificate of necessity.

Provision is made for rehearings on any order of the commission and for appeal to district and state supreme courts. The penalties for disobedience of the orders of the commission are fixed at not exceeding $2000 for each offense, each day of continuing violation being considered a separate offense. Each individual offender, either as individual or an agent of a company, is liable to a fine not exceeding $1000 or to a jail sentence not exceeding one year for violation of commission orders.

EDITORIALS

Wanted: Machinery for Levee Building

The levees along the lower Mississippi River from Cairo to the Gulf contain nearly 250,000,000 cu.yd. of earth, a greater volume than the total excavation on the construction of the Panama Canal. Practically all this work on the Mississippi levees has been done by either hand power or horse power. The negro pushing a wheelbarrow and a team of mules pulling a drag scraper represent the motive power and tools by which almost all this enormous volume of earth has been moved.

At the present time the probability seems strong that a great addition will be made to the Mississippi levees during the next four or five years. The floods of 1912 and 1913, following in such close succession, have aroused the people of the valley to the realization that the present levee system, while it has for a long term of years, from 1897 to 1912, kept practically all the flood waters off the lands of the delta, is not secure enough and high enough to guard against the years of exceptional flood. It is, probable, therefore, that during the next five years many millions of cubic yards of earth will be added to the Mississippi levee line; and there seems to be an opportunity here for the manufacturers who have developed new forms of excavating apparatus and earth-handling machinery and for the contractors familiar with the use of such machines to prove the value of these devices.

We are not by any means urging here the oft-repeated foolishness that the discarded plant on the Panama Canal work should be brought up and utilized for the work along the Mississippi. Every engineer familiar with the conditions knows that the rock-excavating plants used in digging the Culebra Cut would be wholly useless in the conditions prevailing in the Mississippi Valley.

There have been developed, however, a number of new types of earth-moving machinery during the past few years, such as the cable drag scraper, which might possibly prove adapted to the work of Mississippi levee construction. We feel confident that the engineers responsible for this work will gladly coöperate with makers and users of machines which promise to reduce the cost of levee construction and thereby increase the amount of material which can be placed in the levees with the funds available.

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A Regular Semi-Monthly Meeting of the American Society of Civil Engineers outside of New York

The American Society of Civil Engineers has just announced a somewhat radical innovation in the matter of holding its regular meetings. Hitherto the Society has always had an annual meeting in January in New York City and an annual convention in June at some place that might reasonably answer to the name "summer resort," or at least could boast of a climate that would allow pleasurable outdoor activities in June. In addition to these two general meetings, regular semi-monthly meetings have been held in the Society House in New York City, at which meetings the papers which appear in the regular monthly *Proceedings* are read and discussed.

It is now announced that on Oct. 15, 1913, the regular semi-monthly meeting scheduled for that date will be held at New Orleans, La., and not in New York. Full details of the method of carrying on this meeting are not as yet available, but a society announcement gives the following explanation of the reason for holding the meeting outside New York City.

> It has been realized for some time that, with only one annual convention during each year, it is almost impossible to hold meetings which will be accessible to the rapidly growing membership, and there are some localities in which it is perhaps not desirable to hold a summer convention. It is hoped that by this plan one or more additional society meetings can be held each year and that these will serve to bring the somewhat widely scattered membership into closer touch with the Society and its work.

This experiment is, of course, a result of the feeling common among the membership of all the large national societies that the home members, or those living in the immediate vicinity of the home office, receive more than their share of the benefits of the association. In other large national societies a solution of the difficulty has been attempted by the establishment of local branches, but in the American Society of Civil Engineers the local branch idea has not been favored although several of such branches are in operation. The New Orleans meeting and those subsequent thereto, if any are held, will be watched with interest by the other societies that have the same problem to solve.

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Should an Engineer Make Himself Financially Responsible for His Estimates?

At the recent Baltimore meeting of the American Society of Mechanical Engineers, the committee appointed to present a code of ethics for adoption by the Society offered an additional clause to be inserted in the proposed code which has been before the Society for some months, and was published in ENGINEERING NEWS of Jan. 2, 1913. The proposed new clause reads as follows:

> The engineer, in conformity to the practice in other professions, should not offer or execute a bond to guarantee the performance of his work. The client's reliance for the satisfactory execution of his work should be the professional reputation and experience of the engineer.

In recommending the adoption of this clause as a part of the proposed code of ethics, the committee was aware that cases are not uncommon where engineers of good reputation do offer to guarantee their work. It may be well to explain, therefore, the reason which seemed to the committee conclusive why the engineer should not make such guarantees.

It may be said at once that the question as to the

propriety or impropriety of such practice on the part of engineers turns at once on the basic question whether engineering is a profession or whether it is a commercial business or trade. It may be said frankly that where engineering is carried on as a commercial business, in other words where an engineer is engaged in business as a contractor or a manufacturer or a dealer he must be expected to conform to ordinary trade customs and it is entirely proper that he should give guarantees and bonds for the performance of what he undertakes to do. Where, on the other hand, the engineer is engaged in working in a professional capacity, where as an advisor or designer he is in charge of engineering work, it is contrary to the interests of his profession, himself and his clients that he should be called upon to give financial guarantees for his work.

To illustrate what is happening, we may best depict the situation by reporting an actual case that recently came under our notice. The authorities of an important city desiring to build a large bridge, secured designs from a number of leading bridge designers under an offer of prizes for such designs with the understanding that the engineer receiving the first prize should be placed in charge of the construction. Each competitor submitted with his design an estimate of the cost of construction. One of the competitors later offered to give a bond that the cost of the completed structure should not exceed the estimate he had given, and on the strength of this guarantee he was awarded the first prize.

It can readily be understood that such guarantees are very attractive to the average city council. These men are inclined very naturally to say that the engineer who is willing to back his estimate with a financial guarantee shows thereby his confidence in his work and his reliability. Strong prejudice is created at once in favor of such a competitor as compared with another man who follows the professional standard and declares that his reputation and standing must be the reliance of his clients.

Let us, however, follow out the situation a little further, and see where it lands us. The average charge for engineering work on the part of the designing engineer for a bridge costing, say, half a million dollars, would seldom exceed 6% of the cost of the structure. The engineering work performed by the contractor in connection with shop drawings, designs, manufacture, erection, etc., is, of course, not included in this. Out of this 6% of the structure's cost, the engineer in responsible charge of such a work will probably expend in actual money at least 1% upon the work of making surveys, soundings, borings, preparation of design, drawings and estimate, inspection of the material and of the work of erection until the final completion. This leaves the engineer with a maximum profit upon the work for which he bears the responsibility, of 2% of its cost at most; and the average margin of profit will be much less than this, we believe. But the risk of loss involved in a financial guarantee that the estimated cost of the structure shall not be exceeded would represent almost invariably a risk of much more than 2%.

The situation revolves itself then into this: Since in any engineering work there is always a fair chance that the final cost will overrun the estimate by as much as 10%, no matter how carefully and conscientiously the original estimates are made, the engineer who gives such a financial guarantee and who is financially responsible runs the risk that he may have to lose not only the profit on this particular piece of work but all he could make as profit on five to ten other pieces of work of similar size. Every engineer knows perfectly well that the earnings of engineers, even the men who are leaders in the profession, are insufficient to enable them to assume any such financial risk. To do so would be simply a game of heads I win, tails you lose. If the engineer were placed in the position of the contractor where he could keep for himself as profit the whole amount by which the cost of the work fell *below* his original estimate there might then be some reason in making him pay for the extent to which the cost exceeded his estimate.

Again, however, we need to get back and consider what the engineer's estimate is, or rather what it ought to be. If it were common for engineers to guarantee their estimates by a bond, every engineer would make his estimates as large as possible, thus making himself secure against loss. It would be manifestly unwise, however, to place any such premium upon exaggeration by engineers. When a man asks his professional engineering adviser what his estimate is of the cost of a piece of work it is his right to be informed, as nearly as that engineer's ability and experience will enable him to give it, what the cost is going to be as nearly as possible. To have an estimate exaggerated in order that the engineer may gain a reputation for saving money in executing the work is contrary to the client's interest.

Since the engineer has not the financial ability to guarantee the accuracy of his estimate and make the guarantee good, there will result, should such a system of guarantee come into general use, the transfer of engineering work from the independent professional engineer, working with his own brains and with assistants on whose special knowledge and ability he can rely, to the large engineering corporation, relying on its profits from taking engineering contracts and doing the engineering work as an incidental. There are surely already influences enough and tendencies enough toward the elimination of the professional engineer and the performance of free engineering work by contractors without giving the movement further encouragement.

It should be said, however, that it is not in general the responsible, reliable and experienced engineer, by any means, who offers to guarantee his estimate. When a city council is selecting an engineer to prepare plans for a system of water-supply or sewerage or what not, it is generally the competitor of little or no professional standing and reputation and with little or no financial responsibility who is foremost with the offer to guarantee that his work can be performed inside his estimate. It is manifest that financial guarantees from a man who has nothing with which to make his guarantee good mean nothing in reality; yet this sort of talk from a man who can bluff well will often have a strong influence with a city council.

It should not be thought, however, that the subject we are discussing relates merely to the financial guarantee of the accuracy of an engineer's estimate. The question is as broad as the whole range of engineering work and it may be well to say that the clause proposed by the Code of Ethics Committee of the Mechanical Engineers is in conformity to the uniform rulings of the courts and the well known position of the engineer in law.

If an engineer of experience and standing, conscientiously and to the best of his ability carries out a piece of work, let us say for example builds a reservoir to hold water, and it afterwards fails from some cause or other, the law does not hold the engineer financially responsible for the failure of his work, nor can he be held criminally responsible, unless it can be shown that he has been negligent in some respect involving real culpability.

The engineer who undertakes work which he is competent to do and who executes it with care and thoroughness it not held by the law to be the guarantor of that work any more than the law holds the doctor the guarantor of the life of his patient, or the lawyer the guarantor of the soundness of his opinion. Of course either the doctor or the lawyer is responsible to his clients in damages, if through gross neglect and incompetence he fails to do those things which ordinary professional practice would demand and the client suffers loss. A similar rule applies to the engineer.

It need hardly be said in this place that ENGINEERING NEWS, in making the above argument, is not by any means urging that engineers should be released from any responsibility properly belonging to them. Our proposition is that their responsibility should be for their work as professional men; and that no engineer should attempt to assume a financial responsibility that the law does not expect him to take and which his financial condition forbids him from doing if he is to continue solvent.

Can Engineers Be Trusted to Arbitrate Fairly and Intelligently between the Public Interests and the Property Interests?

Senator Robert M. LaFollette, of Wisconsin, is said to have taken the chief responsibility in the drafting of the Railroad Valuation law. In the journal which he publishes, *LaFollette's Weekly*, for May 10, there appeared a leading article headed in large type "An Economist Is Needed." The article, which is signed by Senator LaFollette himself, says that the railroad valuation work should be placed in charge of an economist and not an engineer. We quote as follows:

> The Interstate Commerce Commission faces today the gravest responsibility of its life. By its work in valuing the property of the railroads the Commission will be judged by the American people now and hereafter. It has already announced the appointment of a staff of civil engineers as the first step in forming its organization. Engineers are indispensable, as are accountants and other experts, but it is not believed that engineers will be placed in charge of the work. That is a mistake which has been made too often to excuse repeating.
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> The value of the physical properties is very important and it is essential that the engineers should submit their findings on these factors; but even with these elements, a critical study of construction, repair, maintenance and depreciation accounts may be more illuminating than the engineers' appraisals and in every case will constitute an indispensable check on the work of the engineers. Hence it will be necessary to add to the staff a corps of experts familiar with railroad accounting.
>
> Besides, complex financial operations will present themselves, requiring the most thorough and searching examination. All of these elements, classes of values and all financial operations must be correlated, weighed and interpreted with relation to each other and as a whole. For these reasons the entire work must be under the control of an economist and not of the engineers whose work is to be checked.
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> The valuations of railway property by many, if not all, of the states have been made from the engineering rather than from the economic viewpoint. This has in every case given the railroads the advantage. The engineers who have made valuations of railway property have been primarily trained in the employment of private interests. Their practical experience in that service and in valuing public utilities for purchase and consolidation has always been from the viewpoint of the PROFIT WHICH PRIVATE INTERESTS COULD SECURE FROM THE PUBLIC. The economist by his very training deals with the whole problem from the public's standpoint, that is the standpoint of the JUST RELATION BETWEEN PRIVATE INTEREST AND PUBLIC INTEREST. For every reason, therefore, it is vital to the scientific integrity of this great economic investigation that it should be under the general direction and control of the ablest economist to be found in the country.

Senator LaFollette is unquestionably correct in his statement that questions of economics are deeply involved in the task of railroad valuation. He is right in stating that these economic questions are even more fundamental than the valuation of the physical properties; but he is, in our opinion, fundamentally and absolutely wrong in his statement that engineers are less trustworthy to maintain a fair and equitable relation between the public and the corporations than are the economists.

It is true that there are in the engineering profession, particularly in the branches having to do with the operation of public utilities, many prominent men who by long service with the corporations have acquired a strong bias on that side. It would be easy to name a number of prominent mechanical and electrical engineers particularly who are definitely committed to this side of the question. The attitude of these men, however, does not by any means commit the profession as a whole to any partisan view of the question.

Speaking from a wide acquaintance with engineers in different branches of the profession, we believe there is no class or profession, not excepting the teachers of economics in the colleges, who have a broader and fairer understanding of the economic questions in connection with the valuation of public utilities than have engineers.

As a matter of fact, the work of valuation has been going on, not merely for railways, but for various other public utilities for nearly a quarter of a century; and almost the whole of this work has been done by engineers and has received general public approval.

One in search of sound discussions of the economic and legal principles underlying such valuation will find more such discussion in the proceedings of engineering societies and in the reports rendered by engineers than anywhere else.

On behalf of the engineering profession, therefore, we think it important that a strenuous protest should be made against Senator LaFollette's charge that the engineers who have conducted valuation work in the past have made their valuations "from the viewpoint of the profit which private interests could secure from the public."

To make such a charge, without a scintilla of evidence in its support, falls little short of a libel on the engineering profession. Senator LaFollette ought to know that the engineer, by the very conditions of his employment, is trained from his earliest experience to occupy an impartial position. Every engineering inspector must endeavor to fairly adjudicate between the contractor and the party for whom the work is being performed. The same thing applies all the way up the line. There are hundreds of millions of dollars worth of work in progress in the United States today, the performance of which depends upon the impartial adjudication of the engi-

neer in charge as between the contractor and the employer.

There are unquestionably grave economic questions to be settled in connection with the railroad valuation work, and expert opinions on these questions by leaders of economic thought are highly desirable. These questions, however, are not, by any means new. They have been studied for years by engineers who have been engaged in valuation work and studied with just as full recognition of the interests of the public as is given by Senator LaFollette himself.

The Senator's charge that the work which the engineering profession has already done in valuation of public utilities has been done as the tools of the corporations—for that is the real purport of what he says—has no foundation in fact. On the contrary, we believe, from a wide personal acquaintance with engineers, that, while in their professional work their aim is to effect that evenhanded and impartial justice which Senator LaFollette professes to desire, in the great majority of cases their personal sympathies are with the public interests rather than the property interests.

It happens that within the past few days there has come to us a letter written by an American engineer (a member of the American Society of Civil Engineers) holding a responsible position under a South American Government. The letter was written to a personal friend and not for publication, and we omit, therefore, from the extracts given below all mention of names and places.

The picture which the letter presents of an American engineer, standing up almost single-handed and alone, in defense of the people's rights against conscienceless exploiters is one which we particularly commend to Senator La Follette. Perhaps there are few engineers with such nerve and backbone to stand out in the face of heavy odds; but there are many, we believe, who will cordially coincide with the economic opinions which the writer of the letter expresses.

I have been charged with a responsibility during the last year, which, however much I may exaggerate it in practical effect, is quite important enough to demand from me the most disinterested and unselfish thinking that I am constituted to produce.

A large number of foreign and native corporations, syndicates and individuals, among them several from the United States, have asked for important concessions of land and water, in accordance with the time-worn policy of Latin-American countries to develop their resources by granting them to private persons and associations.

It has devolved upon me to examine these petitions, and the reasoning I have been able to do upon the matter has led me to render an adverse report in all cases. The premises from which I have started in all cases, and the conclusions which I have reached, are at complete variance with the common beliefs and practices here, and I am unable to discover more than one or two persons in this country, of any influence or social or political prestige, who would agree with me with that degree of sincerity that promises constructive action in the face of intrenched interests.

Out of a total population of 4,000,000 people in this country the governing classes constitute probably less than 10%, and the active agents in legislation, administration and politics a much smaller percentage. I do not believe that there is a member of the Senate who is not a wealthy land owner; and the constitution of the House of Deputies is such that it is dominated by the same class. Large numbers of the Deputies are simply pawns in the hands of a few shrewd politicians.

The result has been that for years one law after another has been passed in which, under the pretext of developing the country and promoting agriculture, special privileges have been accorded the owners of the large rural estates, or have been granted to the would be promoter who seems always sycophanting about a weak government. As a result, out of about 1,500,000 acres of arable land on the coast, capable of and requiring irrigation, one-half is under erratic cultivation and irrigation, and of that one-half, as much as 50% is owned and operated in large tracts by a few people. The other half is barren and unproductive, but is owned under "concession," so that there are actually no Government lands.

A law, the first draft of which was made by me, but which was so mutilated by the politicians before it got through Congress as to be absolutely unrecognizable, kept enough of its original form to provide that the Government can expropriate land privately owned, unimproved and susceptible of inclusion within the limits of an irrigation project. But a completing phrase, restricting the price to be paid for such lands and providing for its valuation by an impartial commission, was stricken out, so that we may have succeeded only in giving the politicians another weapon.

Another thing that the brave legislators added to the bill was a clause which gave the Government the power to guarantee the interest upon all or any money invested by private individuals in an irrigation enterprise. The introduction of this clause seems to be absolutely pernicious. In an ideally constituted society of absolutely truthful and honest men, who were, furthermore, experts in business management, such a principle might be safe, but it would, in such a society, become unnecessary from all points of view. If a business is a good and safe one, proven to be feasible by competent investigation, it needs no guarantee. If it is not so and has not been properly investigated, it should in no case be guaranteed by the Government.

I believe that if a Government or any other association of people guarantees interest on funds, they should be their own funds, raised by assessment upon their own resources and managed by them or their own duly appointed representatives; and I believe that as a principle of practical business as well as of abstract administrative science this is true, and that the Government guarantee of the interest upon private capital invested for private gain, upon the supposition that the indirect benefits to the Government in the shape of additional exports and greater population justifies the guarantee, rests upon a fallacy plainly proved by hundreds of analogies in many countries.

The law does not provide that the lands shall be disposed of at a fair price to colonists, nor does it prescribe any form of organization or management to be adopted by the companies enjoying the guarantee. It does provide that the guarantee shall not be granted unless the investigation and design of the projects involved shall have been executed or revised by the Government's Technical Service, and approved by the Government. But if the lands are to form, after the construction of the works for irrigation, a private estate, this clause simply makes the Government's Irrigation Service an employee of private interests.

There are still two means of escape from the ill effect of the law, supposing my reasoning as to fundamentals is correct. An older law, not repealed by the new one referred to, implies in its general purport, that expropriation can in general not take place, unless public utility is proven. The Government can hold, therefore, that unless lands are destined for the use of a community of independent and free landholders, through, for instance the sale of the improved lands at an equitable price and in relatively small holdings to insure freedom from monopoly, the solicitation for a concession under the new law is not justified.

Also, the new law authorizes the Government to issue approximately ten million U. S. Dollars worth of bonds and apply the proceeds to the construction of irrigation works. In pursuance of the policy logically implied by this part of the law, the Government could retire from concession or grant, all lands susceptible of irrigation pending a report of its engineers.

In my treatment of applications for the benefits of the law I am proceeding upon the first of these supposedly possible courses at present, and have succeeded in getting 75,000 acres of land retired from concession pending the decision of the Government relative to its development in accordance with designs and estimates already prepared.

The principle I believe to be fundamental in the whole matter is this. The prosperity of all classes, as opposed to the intense prosperity of a few and the ill estate of the many, depends upon the possession, or the ability and opportunity to possess, by the masses of the peon class, agricultural land in tracts small enough to be workable under intensive cultivation, and large enough to provide a living income.

The correctness of this principle is proven to anyone who will observe in this country, the contrast in physique, intelligence, energy and industry and domestic habits, between the peon who has lived all his life on a big sugar estate and worked for a wage and a glass of rum in the mornings, and the man of the same social origin who has acquired a right in some of the ancient rural communities left intact from

the time of the Incas or before, where he possesses a parcel of land and its produce for his own use.

You will see from the above that the irrigation problem in this country is as much a social problem as a strictly engineering one, and this is probably a corollary to the more general statement that the carrying out of engineering works constantly involves the solution of social problems. I think at any rate I have said enough to show that the conditions here connected with the work I am trying to do are somewhat complex, and that they require unbiased treatment.

So far, I have spoken only of the legislative manipulations of the landed classes. There is another element in the problems that are coming up which I think will interest you as an American and as an engineer. That is, the attitude of the so called "Diplomatice Service" in support of any proposition that purports to be American, and is introduced with a letter from Senator Doe, or some other U. S. Congressman. Recently, Mr. R., a member of a Chicago firm, proposed to this Government a scheme that is in brief as follows:

The Government was to issue two million pounds in gold bonds with guaranteed interest and principal, and sell these to Mr. R. at 87½% of their par value, and was to pay to Mr. R. 15% of the cost of constructing the irrigation works paid for out of the proceeds of the said bonds. It was to pay also to Mr. R. $35 U. S. Currency, for each acre colonized by him, and to allow him to colonize at the rate of one man to each 150 acres, and to give Mr. R. the exclusive power and authority to construct and operate all railroads, telephone and telegraph lines, moles, wharves and docks, to manufacture all structural materials, cement and brick, to build all houses, to establish all ice and cold-storage plants, etc., within the territory irrigated, for a period of fifty years.

The clause relating to colonization provided that the colonist himself need not appear in person, but might authorize a representative to select his land and that this written authority and the payment of one pound per hectare, should be proof of colonization and oblige the Government to pay the 18 pounds per hectare referred to in the contract. Also in the clause relating to construction, Mr. R. was to be given plans and engineering data, and receive a fair profit, 15%, but without assuming the responsibilities of a contractor in any sense.

I have had to advise unfavorably upon this proposition, but the U. S. Minister here has done all he could to get the Government here to accept it, and has gone so far as to say to the Government that if the proposition were accepted it would be a guarantee that there would be no more trouble with this country's hereditary foe.

It seems to be the attitude of these gentlemen that I ought to support any rascally scheme that they get up to "do" these people simply because they and I are Americans. I cannot see the patriotic side of this proposition.

I am strongly opposed to these legislators who are bartering away the resources and the moral vitality of their country; but I see no essential difference in their aims and the aims of these gentlemen who want to get everything for nothing and monopolize all the public utilities that can ever exist within the territory to be irrigated or improved.

It is not a question of race or color, or nationality, but a question of right and wrong. It may be true that this country is not competent to govern itself, but are foreign monopolies competent or likely to govern it for the benefit of the greatest number? If so, the best proof they can offer is a fair and equitable proposition in which they show a decent restraint from playing the hog and the despot.

I do not believe that the Government, however incompetent, could do much worse than the foreign corporations here have done, especially the English and American corporations. Foreign-operated railroads charge an average freight rate of 10c. per ton-mile, U. S. Currency. Foreign-operated mines pay no royalty, provide no protection to native workers, send the copper and the dividends out of the country, and flood the country with a swaggering retinue that are doing more in South America to alienate good will from us than any other element.

One hears from the average man who has traveled in these countries that the Government is corrupt. It is not so corrupt as it is inefficient. The corruption arises largely from the abuses that are easy to the clever manipulator in an inefficient organization.

What is to be the future of this country is a puzzle. So far politics has engaged all the President's time, and that of his cabinet. If foreign capital will not come into the country on a basis that permits a rural population to live in better condition than that of the laborers upon a large plantation whose products are sent to Europe and North America, then I do not believe that foreign capital should get in.

If the Government cannot now float its bonds so as to build and operate its own irrigation works, let it wait until it can.

The country is not suffering, there is no immigration of poor Europeans, or any other kind of immigration, there is no crowded population. Why should public works be built today at any cost to the country, depriving the nation of its resources, when by waiting a few years, land values will rise and interest rates fall to the point where capital will have to strike a different attitude.

In the meantime, we will have the advantage of added education, increased legislative and administrative intelligence and efficiency, and a larger understanding of what the national resources are capable of producing if properly managed. The importance of this point of view to the nation will be appreciated when it is understood that there are only a million and a half acres of arable land on the coast, the part of the country that must for many years sustain the center of population and culture of the nation; and if this goes today into the hands of monopolies, there will be no democratic future for the country.

LETTERS TO THE EDITOR

The Problem of Protecting the Younger Members of the Engineering Profession

Sir—I have been reading with interest the letters in ENGINEERING NEWS in regard to licensing engineers as a protection to the profession. In that connection I am taking the liberty of calling your attention to a point which I think is of vital interest to myself and many other young and relatively inexperienced engineers.

The following advertisement is taken from the "Situations Wanted" column of the Washington *Post*:

CIVIL engineer—Employment by all-round field man; $1.50 day.

You will note that the gentleman desiring employment dignifies himself with the title of "Civil Engineer," yet he values his services at only $1.50 per day. I frequently note similar advertisements in the newspapers.

A few years ago I was honored by having the degree of Civil Engineer, conferred upon me by a recognized engineering school, and since then I have had a varied line of experience in field and office in the East, North and West. I am at present employed by the government in the capacity of an engineer.

But I cannot as yet really call myself an engineer in the light that the recognized men in the profession are called engineers. I feel that at least 12 to 15 years of experience are required before one may attain that distinction. Yet this man boldly subscribes himself "Civil Engineer." He may be all he claims, but in that event there is something wrong somewhere if his services as a Civil Engineer are worth only $1.50 per day.

I graduated from college without money, friends or "pull" to help me secure any kind of a job and everything I got was by my own nerve. And during my four or five years of experience, the hardest thing I have en-

countered in getting work is the competition with the fellow who has served as utility man on a party for two or three seasons, who calls himself an engineer, and will work for half of what I feel that I am worth as I gain experience. Until the last year I have been forced to start work in the spring at less than half the pay I was getting when I was laid off when work stopped the fall before. And pardon my apparent conceit when I say that I carried some recommendations from previous employers of which I am proud.

I know several others of practically my age and experience who have had no "pull" and who have encountered the same difficulty, so that I feel our trouble is not all due to lack of ability and poor address.

I do not feel competent myself to suggest any possible remedies for the conditions noted above; so in the interest of my fellow "youngsters" in the profession, I am taking the liberty of asking you to suggest the subject to the prominent men in the profession that they may consider us younger men when considering protection for the engineering profession in general.

ROBT. TRULLINGER.

Washington, D. C., May 20, 1913.

The Grouted Foundation at the Lahontan Dam

Sir—In your issue of May 8, 1913, p. 969, I note your editorial comment concerning the grouting of the Lahontan Dam of the Truckee-Carson Project of the U. S. Reclamation Service, an article covering this work written by D. W. Cole having appeared in your issue of Apr. 3, 1913, p. 647. In your comments you state that the estimated saving of the grouting process over that of an excavated and concrete-filled trench is but $3300.

The above amount, by reference to the article, will be seen to represent only the saving between the cost of the grouted cutoff and the estimated cost of excavating and filling with concrete a trench to the same depth and does not take into account the loss and expense incident to the delay in program which the excavating and filling of the trench might involve.

The writer, because of previous experience in pressure grouting, was connected with the work under a temporary assignment and it was his understanding at the time, as also is inferred by Mr. Cole, that it was the question of time more than anything else which led the U. S. Reclamation Service engineers to the adopting of the grouting program. Had the excavation of the trench delayed the completing of the dam by as much as a year, as I understand was feared, the consequent maintenance of the work, depreciation of plant, and delay in supplying water to the project would have made an indirect difference in favor of the grouting aggregating many thousands of dollars. In this saving of time lies a great advantage in favor of pressure grouting, which, as at Lahontan, may be done through casings while the river flows uninterrupted on its course.

You also speak of a double line of holes being put down to a depth of 30 to 70 ft. If Mr. Cole's article be looked up it will be found that while two rows of casings were put down those of but one row, with the exception of some four or five holes put down for proving purposes, were drilled through, so that in effect the work was accomplished with but a single line of holes on 3-ft. spacing.

I think no one will take issue with you that as between a concrete-filled trench and a grouted cutoff the former is to be preferred when costing but $3300 or 33% more than the latter. Certainly such, were there no other consideration, would be the judgment of the very able engineers directing the work of the Reclamation Service. The repair of the cutoff of a high earth dam, such as the Lahontan, is a very serious matter. With a masonry dam the water can be drawn off, if need be, and a supplementary cutoff put down, and grouting or other treatment resorted to. This is not so much the earth dam, as some—even in recent years—have learned, if not to their own sorrow at least to the sorrow of those putting up the money. The Lahontan Dam has a 30-ft. concrete cutoff and the grouting was an added insurance warranted by the earth type of structure and by the fact of the location in the somewhat peculiar "sink" region.

H. A. RANDS.

Oregon City, Ore., May 19, 1913.

A Joint Railway Organization for the Inspection of Structural Steel and Steel Rails

Sir—In your issue of May 15, you publish a communication from Albert W. Buel, calling attention to the minority report of the Committee on Iron and Steel Structures of the American Railway Engineering Association. The idea there suggested of forming an inspection organization supported by a number of railway companies, united on a mutual interest basis, is not new. Morgan T. Jones has been spreading this plan among railway engineers and executive officers for several years. In June, 1907, a letter by him was read before the American Society for Testing Materials with a view to opening up this subject and laying the matter before engineers generally. It appeared then that such a suggestion would have been regarded as too radical.

The campaign was continued by Mr. Jones, in personal interviews; and in 1912 a comprehensive scheme of organization was worked out and the matter was laid before the American Railway Association, the executive committee of which was "of the opinion that the subject is not one which can be considered by the American Railway Association."

In March, 1913, a pamphlet relating to railway material inspection was published by Mr. Jones, setting forth the proposal that the railways get together and operate an inspection department under one head. A means of financing the organization was suggested and the scope of its more important activities outlined. It was very gratifying to him to find the recommendation, even of a minority of the Committee on Iron and Steel Structures, to be so thoroughly in harmony with his own efforts in behalf of higher efficiency in the field of inspection (and consequently manufacture) of railway materials.

The undersigned, while heartily indorsing this movement, wishes to take issue with Mr. Buel on several points. It is not fair to hope that a "trust of inspection bureaus" could show better results. In all lines of industry it is the competition of growing organizations,

headed by capable and conscientious men, which keeps the overgrown combinations from becoming utterly worthless from the standpoint of efficiency in any other line than that of the concentration of wealth for the proprietors. As long as inspection is conducted as a money making enterprise, competition will be of advantage to the purchasers employing this service. A trust would eliminate the stimulus to efficient inspection, and would not concentrate the power necessary to bring about some needed radical reforms in manufacture. This power can be concentrated only by uniting the buying power of many purchasers and backing a common representative, which representative they control. In other words, these purchasers (the railways) should unite to maintain an inspection bureau on a coöperative basis.

It is implied in the minority report that men with training as draftsmen and computers make better inspectors than men having training in the more responsible positions in the shop. The experience of the writer leads to quite the opposite opinion. The technical man is constantly raising questions in regard to design and character of details which have been settled by competent men before they reach him. Not until he has had several months' experience, under good coaching, does he know what he is in the shop for. The practical man, working under an experienced engineer, makes a far better inspector. Company inspection is usually less efficient than bureau inspection because the companies usually draw on their drafting force for inspectors. By uniting to maintain a company bureau with a properly constituted force of inspectors who are specialists, the advantages claimed for each system could be combined and better inspection at a lower cost would result.

It may be true in the case of some inspection bureaus that the time of the head men is fully taken up by business management and soliciting. This feature would be overcome by the organization proposed. The clientele of the bureau would be established and limited by the "stockholders list" and the entire energies of the officers could then be devoted to securing efficient inspection. It is said that, with two or three notable exceptions, one looks almost in vain for the name of a bridge engineer in the bureau organization. The writer is pleased to learn that the organization which he serves as manager is in a small class of "notable exceptions."

Mill inspection can be greatly strengthened through an organization having the united backing of a large percentage of the railways. Many of the errors in method which have been introduced gradually into the process of manufacturing rails, in order to increase tonnage output, could have been snubbed in their inception had such a bureau existed ten years ago. The problem now is to compel a restoration of correct methods, and this can be done only by united effort which will make reform a business necessity.

This brings us face to face with another issue of this movement, the production of better rails. The minority report of the committee above referred to has lightly dismissed this feature as something to be considered later on, and in taking this stand this committee has failed to see and improve its opportunity. Purchasers who are now served by inspection bureaus of the better class, are securing bridge material which is quite satisfactory both as to quality of steel and workmanship, and 18 years of specializing in this field of construction have brought to the writer's attention ample evidence in support of the above statement. Railway accidents due to the failure of steel structures are few.

This cannot be said of steel rails. During six months, beginning with October, 1911, and ending with March, 1912, there were 277 accidents due to broken rails, in which 22 people were killed and 768 injured. Volumes of statistics can be cited pointing to a very urgent need for better rails. Any proposal for the saving of life and limb and public and private wealth is not a matter to be lightly referred to as a future possibility. It demands immediate and serious consideration.

The railway companies by subscribing to the organization of a bureau of inspection and giving it their united support, will be in a position to bring about many such needed reforms in manufacture of railway materials. The result would be cheaper and at the same time better inspection. This would unquestionably result in better material and more harmonious relations between purchaser and manufacturer, which is sadly needed.

P. E. Stevens,
Mgr., Morgan T. Jones & Co.
Monadnock Block, Chicago, May 21, 1913.

The New York Water Filtration Controversy

Sir—Your last number devotes much space to what you call "The remarkable hold-up of the New York water filtration project," in which you state that it "has no apparent engineering justification" and cite me as one of the opposition. Permit me, therefore, to state the reasons for my views and to call your attention to some points not yet clearly brought out.

Beyond doubt, as you indicate, the people of New York are justly entitled to water that shall be "disease-germ-free, clear, colorless, tasteless and odorless." The city government is certainly bound to do its best to deliver water free from typhoid infection.

The typhoid rate of New York is very low and is getting lower. A reasonable allowance for cases caused by bad milk, uncooked vegetables, travelers and "Typhoid Marys," leaves only a very small percentage as possibly caused by the water-supply. In Washington, excellent filters caused no apparent change in typhoid.

On the other hand, the city appears to have been quite negligent in protecting the supply against contamination. Railroad trestles directly over the reservoir with no catch-pans under them, bridges without similar pans, house sewers and stable drainage going directly into the tributary streams (for which small cesspools could be easily substituted) and a very small police to enforce such sanitary regulations as exist, are among the things neglected. This neglect is far more than enough to account for the little typhoid that could possibly be attributed to Croton water.

Filtration is the standard way of making a safe water. It is not the only way, and the proposed mechanical filtration may not be the best way. For example, the United States Military Academy at West Point is supplied with an exceedingly high-grade water from surface streams, with a settling reservoir but no filtration. Filtration takes a very bad water and makes it so good that the difference is startling, but it is by no means perfec-

tion. It does not remove all the bacteria, possibly not all the dangerous ones, and mechanical filters are subject to errors in judgment. If neglected, they give dangerous water.

As opposed to the possible benefits of the proposed mechanical filtration, is the undoubted fact that the use of coagulants converts the temporary hardness, which is not a serious matter in the water, into permanent hardness, which is. Such hardness makes boiler scale, and boiler scale makes a tremendous increase in the quantity of coal required to make steam, and when one considers the number of boiler plants in the city, there being a pretty lusty boiler to every big building, the matter seems no trivial one. It is proposed to remedy this by putting the water through a softening process. This is expensive and has seldom, if ever, been applied to a supply as big as the Croton.

Practically all the reports on the improvement of Croton water are based upon the water *as it is* and not *as it will be* or easily *can be made* by the time the filters could be built. Apparently, the enforcement of the minor matters outlined above would leave Croton water objectionable only in the matter of color, taste and odor, all due to an excess of vegetable matter in the water. This seems to be almost entirely due to shoal places within the reservoirs. The marine vegetation on these shoals is killed when the water falls and bares the shoals to the sun. The land vegetation, which grows when the shoals are bare, is killed when they are again flooded. A comparatively modest amount of dredging and the building of a few dry, stone retaining walls, should go far toward remedying this at a comparatively small expense. The use of a trifling amount of sulphate of copper in the reservoir would destroy all the algae, to which a large part of the objectionable features are due.

This same excess of vegetable matter appears to interfere with the use of hypochlorite, which at other places, in very minute quantities, has proved more effective against typhoid than any known filter appears to be. Another difficulty in this behalf is stated to be the great variation in the quality of the water, a rainfall of two inches making a very bad effluent. It seems to be overlooked that this condition can be easily remedied when the new water is received from the Catskills, which will be long before the filtration plant could be made ready. Reservoirs filled from the Catskill supply can readily be drawn upon for a short time after excessive rains to give the Croton a chance for the bad water to be wasted or to be properly settled. Sedimentation is a most excellent way to get a pure, clear and wholesome water.

After the above precautions have been taken, a little aëration at a negligible expense would probably remove entirely the objectionable tastes and odors. In addition, cleaning out the city pipes and city reservoirs, necessary in any case, would doubtless add materially to the improvement. Practically all these things are recommended by those who advocate filtration, *after* the filters are built. As there are no immediate dangers in Croton water, why not try them first?

Engineers advocating filtration say that no water from the Catskills can be spared to help out the Croton; that the Catskill water is entirely for Brooklyn, Queens and Richmond boroughs, to save pumping costs; and that not even an occasional reservoirful can be spared to help out the Croton supply for Manhattan and the Bronx after excessive rains, and yet at least one of these engineers, a few years ago, recommended the award of the Ashokan Reservoir contract in the Catskill supply to MacArthur Bros. & Co. at a price over $2,500,000 above the lowest bid, that of John Pierce, on the ground that the lowest bidder would probably be slow with the contract and that haste was necessary on account of dangers of a water famine in Manhattan and the Bronx because the Croton supply was getting short. This apparently excessive zeal for building water-works together with the reasons given above, certainly justify the Board of Estimate in making haste slowly.

To my mind, a far more important reason exists in the specifications upon which bids were obtained. Fairness and economy in public contracts are as vital to a city's welfare as pure water. The specifications concerned are quite commendable with a few exceptions, but at least one of these is exceedingly important.

The most difficult matter in which to insure fair competition and economy lies in obtaining patented articles. In filtration plants of the type proposed, a few patented appliances have been found in some cases desirable, although I believe a practically perfect plant can be built without any of them. They consist of a few simple strainers, some devices for regulating water level and a few for convenience in operation. The commission of engineers which was favorable to filtration stated that the royalties on filtration patents thus far have been small and that all the more important patents will expire within a year or so after the earliest date at which the Jerome Park filters can be completed.

Yet, we find in these specifications that the small patented articles, instead of being entirely avoided or obtained under competition covering them alone, were lumped in the whole plant, and the inherent difficulties in their purchase was made to contaminate the competition of the entire plant and, quite probably, to entirely dominate it. This is wrong in principle and fully justifies the adverse vote of the Board of Estimate.

Alternative bids, too, are always objectionable, and pave the way for juggling contracts into the hands of favorites. In these specifications, there were six alternative ways of bidding, based on six different systems of operation, and these, in turn, hinged upon the objectionable patent features.

While it is stated in the specifications that any one of the six systems will "be satisfactory," there is nothing to prevent the award of the contract to a favorite on the ground of his system being more satisfactory than the others. Had the specifications said that the different systems would be equally satisfactory, the case would not have been so bad.

As it was, the importance of the patents was magnified in the specifications by the requirement of a large bond, $150,000, required for six years to protect the city against suits for infringement. This put a club worth pretty nearly $150,000 into the hands of whatever bidder could succeed in tying up all or most of the patents, but as if this were not enough, while the very large bond, $1,000,000, was given in the printed specifications as a bond simply for the faithful performance of the work, it was, I am reliably assured, in the specifications actually issued to bidders, altered to make it to also

cover the patents for a year after the contract was completed.

The normal difference in bids between the lowest and the next lowest for a contract of this size and character should be less than $100,000, and the above arrangement may fairly be considered as enough to put the contract into favored hands.

Any contractor who had previously used these patented appliances, would have a distinct advantage, and it is to be noted that the McNichol concern, which was the lowest bidder, had previously built a large set of similar filters in Philadelphia, in which they were awarded the contract under precisely similar alternative bids, which award was made as a matter of legitimate jugglery, there being only one way out of six possible that the McNichol could be figured the lowest bid.

It is to be noted here that the City of Baltimore has recently opened bids under specifications on all fours with the one under consideration, and that the McNichol concern was again the lowest bidder, but the bids have been rejected, and in the readvertisement, the patented articles are to be bought separately.

In this behalf, it is to be noted that the Jerome Park specifications call for bids carefully itemized in painstaking detail until it comes to the operating mechanism involving patents, for which a lump sum bid amounting to upwards of a million dollars is called for. All this mechanism is merely standard piping, easily itemized, and yet the patent virus is made to contaminate this big item, and then, the whole filter construction is tacked on to it. There would be equal justification in adding in the paving of a few dozen city blocks in the vicinity.

It has been argued all along the line that the impressive list of bidders cures all possible defects in the specifications and bidding. I beg to differ from this view. In the Cumberland Sound improvement contract, some years ago, amounting to $2,350,000, there was a nice array of three bidders with bids very close to each other, and yet the work could have been done for less than one-fifth of the lowest bid.

It is to be noted that the array in the Jerome Park Filter bids is one of competent bidders and that there are not many large contingencies in the construction itself; also that while the bids generally range quite uniformly in differences, McNichol's, the lowest, is over a half a million dollars below his nearest competitor. This indicates his concern had some big advantages somewhere.

Another point, the six alternative bids are based upon washing the filters with or without the use of air and using or not using "negative head." For any particular plant, these items have a more or less important engineering bearing. Only one system is the best. The city engineers should have determined in advance which one was best and obtained bids on that alone.

Some of the specifications are so severe as to be practically impossible of execution. The clay called for as specified literally could probably not be found in nature. This criticism may appear captious, but yet a contractor in Philadelphia who was the lowest bidder for a reservoir at about $500,000, the McNichol concern being next, at about $1,250,000, was ruined and practically driven to his death by the literal enforcement of almost precisely the same specification.

Note further, the fact that the moral blight under which the city government of Philadelphia has withered for years is entirely due to the domination of contractor bosses, compared to which blight the blight of typhoid is a bagatelle, and you have a final reason for the wisdom of the Board in postponing the letting of the contract till both the Croton watershed and the specifications can be "cleaned up."

CASSIUS E. GILLETTE.

Land Title Building, Philadelphia, Penn.
May 26, 1913.

[There follows a reply to Major Gillette's letter, from I. M. de Varona, chief engineer of the Department of Water Supply, New York City. We might add that portions of Major Gillette's letter, and particularly the last paragraph, suggest that his experiences at Savannah on government work and at Philadelphia on municipal water-supply and filtration seem to have filled his mind with the notion that all contractors and public officials are rascals, and that engineers as a class are not much better; and that in his zeal to kill what he regarded as another "job" he has overlooked some of the fundamental principles of water-supply and filtration and of engineering ethics as well.—ED.]

Sir—I return herewith copy of letter from Major Gillette, in regard to the filtration of the Croton water, which you forwarded to me.

This subject was so fully discussed in your issue of May 22, 1913, that further encroachment on your valuable space, with the statements of Major Gillette or comment on them, seems to me hardly warranted. I will, therefore, treat the matter as briefly as possible.

The alleged neglect in protecting the water-supply from contamination is Major Gillette's opinion, but not a fact.

That Major Gillette evidently is not familiar with our plans for mechanical filtration, is shown by his offhand criticisms. The amount of permanent hardness in the Croton water is negligible and will so continue after the use of coagulants. It is not true that the Department proposes to put the water through a softening process, because it is not necessary. The method of reducing the carbonic acid would also somewhat reduce the hardness, but that is not its purpose.

Major Gillette speaks very glibly of the easy manner in which the Croton water can be sufficiently improved by the adoption of such minor treatment as a "comparatively modest amount of dredging," the building of a few "retaining walls," the use of "a trifling amount of sulphate of copper" and "a little aëration at a negligible expense." This is a trivial and airy method of dealing with an important matter with which the writer is evidently unfamiliar. He reveals lack of knowledge of the conditions in the watershed, and his wholesale characterization of the expense involved in these various processes as trifling, betrays also lack of study. The various measures to which he alludes are not new. They have been considered by this Department and it may safely be asserted that the aggregate expense involved in carrying them into execution would be far from negligible and by no means compensated by the probable improvement in the water. Still less could they be accepted as an adequate substitute for filtration by any experts.

In the letter under consideration it is assumed that the Catskill supply can be used to replace that from the Croton when the latter is unsatisfactory. Major Gillette would be much embarrassed in proving this proposition, which is certainly not in accordance with the opinion of the engineers who have studied this matter and are conversant therewith.

As to what Major Gillette thinks he could have done to improve the specifications, it may be fair to remind him that, if we are correctly informed, in a proposed contract for the Queens Lane Contingent of the Torresdale Filters, which we are told was prepared under his direction, he was able to obtain only one bid and that bid was rejected, as we understand, because it was considered too high.

Referring to the alternative ways of bidding, Major Gillette alleges that there was nothing to prevent the award of the contract "to a favorite on the ground of his system being more satisfactory than the others," and adds that if it had been stated that all the systems would be equally satisfactory, the case would not have been so bad. This is certainly ridiculous. The specifications clearly say that any of the six types of filters designated "will satisfactorily do the work required for the filtration of the water and bidders may, therefore, bid upon all these types or any one of them," and under the city charter the lowest bid had to be accepted and we so recommended.

Major Gillette's intimation that the numerous bids received from responsible contractors did not indicate that the prices submitted represented the fair cost of the work, is simply a further indication of his characteristic disposition to criticize on general principles. Four of the bids were below the engineer's estimate and said estimate had been indorsed by all engineers who examined it. The further statement that "the normal difference in bids for a contract of this size should be less than $100,000," will be condemned as absurd by engineers having experience in the construction of large works. We challenge Major Gillette to show us a record of work of this character and to this atmount ($5,000,000), for which half a dozen bids have been received, in which the difference did not exceed $100,000.

It is not true, as Major Gillette asserts, when referring to our filters, that a certain firm "had previously built a large set of similar filters in Philadelphia in which they were awarded the contract under precisely similar alternative bids, which award was made as a matter of legitimate jugglery." Our alternative bids *are not precisely similar to those prescribed in Philadelphia.* In fact they radically differ. In our case there cannot be any jugglery, legitimate or illegimate.

As to the criticism of the specifications for clay: They are practically the same as have been used on all important work of this nature anywhere in this country, and no other criticism except that of Major Gillette has hitherto been made of them, although we, of course, admit that an arbitrary interpretation on the part of the engineer would prove damaging to the contractor. That, however, would be the case with any other item or any other contract.

Major Gillette further risks the following statements:

> The importance of the patents was magnified in the specifications by the requirement of a large bond, $150,000 required for six years to protect the city against suits for infringement. This put a club worth pretty nearly $150,000 in the hands of whatever bidder could succeed in tying up all patents, but as if this were not enough while the very large bond, $1,000,000, for the faithful execution of the contract was in the printed specifications as a bond for the faithful performance of the work, it was, I am assured, in the specifications actually issued to bidders altered to make it to cover the patents for a year after the contract was completed.

The above statements conclusively show, in our opinion, that Major Gillette does not know what he is talking about. The cost of the $150,000 bond would be 1% per annum, or $9000 in the aggregate for the life of the bond (6 years). This is far from "a club worth nearly $150,000."

In all contracts of this Department and we believe in those of all the other departments of the City of New York, the security bond guarantees not only faithful performance of the work but also indemnity from losses due to patent claims. Furthermore, in all contracts of this Department for work of this kind the contractor is responsible for repairs due to defective work for materials for one year after the completion of the work, so that in this instance we simply followed the usual practice of this Department and the provisions of the contract in regard to protection from patent claims up to one year after completion of the work were the same as in all other contracts. The contract and specifications were printed and bound together and copies thereof were furnished to prospective bidders. No other specifications were forwarded to anyone.

Referring to the patent question, the specifications are thus criticized:

> We find in these specifications that the small patented articles instead of being entirely avoided or obtained under competition covering them alone, were lumped in with the whole plant, and the inherent difficulties in their purchase was made to contaminate the competition of the entire plant and, quite probably, to dominate it. This is wrong in principle and fully justifies the adverse vote of the Board of Estimate.

In works of this character, it is customary to group the various articles in filter equipment in one item, for convenience and simplicity in handling the work. The question is one of judgment in each case. In the present one it was considered for the best interests of the city to so frame the specifications as to secure not only competition, but satisfactory bidders, and the results obtained from the bids submitted conclusively show that they accomplished their intended purpose.

The imputation that the patented articles were lumped in order to "contaminate competition, * * * * and, quite probably, to entirely dominate it," is, therefore, unwarranted by the facts, and against the evidence.

There is no question that in any city a combination of dishonest municipal officers and dishonest engineers can practically ruin a contractor under almost any specifications that can be written, and it seems to have fitted Major Gillette's purpose to assume that such conditions exist in our midst. From *his* hypothesis we confidently appeal to our citizens and to our records, and from *his* criticisms, to the judgment, fairness and decision of the engineering profession.

I. M. DE VARONA,
Chief Engineer Department Water Supply.
New York City, May 31, 1913.

Sir—In view of the editorial comment in your issue of May 22 regarding the plan for mechanical filtration of Croton water, we respectfully call your attention to the following facts:

As you know, the Board of Estimate and Apportionment of New York City voted unanimously (on the same day that the issue containing your editorial was published) to rescind the authorization of corporate stock for this filtration project. It appears, therefore, that the city officials with whom the responsibility rested of passing upon the question were unanimous in accepting the view urged by the Citizens Union, the Bureau of Municipal Research and other civic and taxpayers' organizations that the expenditure for filtration was not justified.

The decision rested largely with President John Purroy Mitchel, of the Board of Aldermen. Mr. Mitchel invited into conference the water commissioner and the engineers upon whose advice he [Mr. Mitchel] had acted as well as the Citizens Union and the engineers by whom it had been advised. The water commissioner was present at this conference with the following engineers: Allen Hazen, J. Waldo Smith, George W. Fuller, Nicholas S. Hill, Jr., Merrit H. Smith and George A. Johnson. The Citizens Union was present and represented by the following engineers: Major Cassius E. Gillette, of Philadelphia, R Walter Cruezbaur, Alexander Potter and Charles W. Parmelee, of New York City. John H. Frazee, an assistant engineer of the finance department, who as a member of the board of consulting experts appointed by the Board of Estimate and Apportionment had presented a minority report against the filtration project, was also present.

President Mitchel limited the discussion entirely to the question of whether filtration was necessary. He particularly desired to have answered the following question: "Is it possible by use of hypochlorite of lime to remove bacteria from the water so as to make it a safe water?" The engineers representing the Citizens Union answered this question in the affirmative and submitted many data showing the successful use of hypochlorite of lime in other cities. Engineers representing the water department stated that chlorination treatment was insufficient and unsatisfactory and would not sufficiently purify the water. Their answers were substantially the same as George A. Johnson's statement contained in the article printed in your issue of May 22, as follows: "All other means, such as forestation, sanitary patrolling, sedimentation, sterilization of the partially clarified water as it leaves the reservoirs, are insufficient and unsatisfactory and filtration is required."

The next day after this conference we submitted to Mr. Mitchel copies of sworn testimony given a few years ago by Messrs. George W. Fuller and George A. Johnson in the case of the Mayor and Aldermen of Jersey City against the Jersey City Water Supply Co., in which the question at issue was whether or not it was necessary to filter the Jersey City water-supply. Messrs. Fuller and Johnson appeared as witnesses for the water company, which contended that filtration was not necessary.

The Jersey City water-supply comes from a watershed consisting of 121 sq.mi. The Croton watershed contains 360 sq.mi. The population of the New Jersey watershed was, at the time of the trial of the action mentioned above, 25,000, the same as the present population of the Croton watershed.

Mr. Fuller testified as follows on the question of the chlorination treatment:

> I think that this process produces a safe water and one which in its efficiency as a process compares very favorably, indeed most satisfactorily, in fact, with the best filter plants as regards both construction and operation of those filter plants. In other words it meets the plan which is represented by the best practice in the art of water purification. I am speaking, of course, now with regard to the removal of objectionable bacteria; that is the very point at which the process is aimed. . . . .

Mr. Johnson testified as follows on the question of the chlorination treatment:

> Q. What is the quality of this water, after this treatment, as to safety and potability, in your opinion? A. I think it is perfectly safe for all domestic and industrial uses.
>
> Q. Is this method, in your opinion, reliable? A. Yes, sir.
>
> Q. Is it safe?. A. Thoroughly.
>
> Q. Is it uniformly effective in its action? A. Yes, sir, always.
>
> Q. In your opinion is this method suitable, or otherwise, to be applied to Jersey City water-supply, for the purpose of rendering it safe and potable at Jersey City? A. I think it is in all ways thoroughly suitable and safe.
>
> Q. Is this method, in your judgment, a practical method for continuous use, to keep this water pure? A. Yes, sir, it is.

In view of the diametrically opposite statements made by these engineers on the question of the treatment of these two water-supplies, Mr. Mitchel could not very well have taken any other attitude or made any other report to the Board of Estimate and Apportionment on this subject than he did.

J. O. Hammitt, Secretary,
Citizens Union of the City of New York.
41 Park Row, New York City, May 26, 1913.

[The second paragraph in the foregoing letter does not accord with our understanding of the significance of the action of the Board of Estimate on May 22. Mr. Mitchel held the balance of power and thus became a sort of umpire in a factional controversy in the Board of Estimate. When he announced his decision against filtration, the project was killed. The subsequent unanimous action by the Board of Estimate amounted to an agreement to bury the dead, or in other words to rescind the resolution authorizing bonds for a project which had been killed after a long struggle.

The balance of the letter, and particularly the last sentence, indicates that Mr. Mitchel decided against filtration because the engineers brought in by the Citizens' Union asserted that hypochlorite disinfection was an equally good safeguard against dangerous bacteria, and that he threw overboard the contrary opinion of a half-dozen engineers because two of them (who speak for themselves below), in the famous Jersey City water case, had testified that reliance could be placed upon hypochlorite to make Rockaway River water safe. We believe Mr. Mitchel is too shrewd and experienced a lawyer to have been much influenced by the excerpt from the testimony cited above, dissociated from the opposing evidence in the same case and from the underlying causes of the Jersey City litigation. We give him credit for having based his decision on what appealed to him to be broader grounds.

Had Mr. Mitchel decided against filtration two years ago, instead of joining, as he then did, in marshaling the evidence for it and in recommending it, the city would have saved the $100,000 or so which it has spent on plans for filters. The readily available evidence for and against filtration has changed so little in two years that a decision for it two years ago and against it now is a virtual confession of lack of proper investigation at the earlier date. Of course Mr. Mitchel does not stand alone

in this confession, which, with the consequences of the negligence, is a sorry piece of business in these days of municipal research, reform and efficiency.—ED.]

Sir—I have read the foregoing letter of Mr. Hammitt and particularly the citation of my views as to the removal of objectionable bacteria from the Jersey City water-supply by the hypochlorite treatment. Those views were stated early in 1909, some five months after this treatment was first regularly applied to a public water-supply.

With the premises the same, my conclusions remain unchanged. But in the Jersey City case there was no attempt made by me to assume that the hypochlorite treatment was a substitute for filtration, which process received no direct consideration in that lawsuit. I stated views as follows:

Q. What in your judgment is the propriety, or, is it in your judgment a proper method to adopt at the Boonton dam for the rendering of this water pure and wholesome for use at Jersey City?

A. I think it is, assuming in my answer that it is the objectionable bacteria which it is the purpose to remove. I might add a word more, that is, that that qualification was intended to refer to the fact that this is not a substitute for filtration; it is not a process to remove mud or the coloring matter which we call vegetable stain, such as comes from decomposed leaves in swamps.

During the past four years a vast fund of experience has been accumulated as to chlorination. Among other things it has been found that some waters are far less suitable in a raw condition for an advantageous application of hypochlorite than was indicated by the early data at Jersey City. The Croton supply is one of those waters in which at times it is difficult to destroy objectionable bacteria by the hypochlorite treatment, without using quantities of the chemical such as to give to the treated water objectionable tastes and odors. This has been testified to at length by D. D. Jackson, Laboratory Division, Department of Water Supply, as well as by Ernst Lederle, Commissioner of Health, New York City. It was explained by me at the conference in Mr. Mitchel's office on May 20, 1913.

To those interested in ascertaining the truth as to the fallibility of the hypochlorite treatment, reference is made to the Croton analyses published in ENGINEERING NEWS of Feb. 27, 1913. The strongest statement of all was that made by Mr. Johnson in Mr. Mitchel's office on May 20, 1913, as to his recent investigation of the shortcomings of this process at Jersey City. A conclusion drawn in 1913 as to the hypochlorite treatment for the Croton supply, based on Jersey City evidence of 1909, is not justifiable.

Another erroneous conclusion drawn by Mr. Mitchel, in his statement at the Board of Estimate meeting on May 22, was that the color and turbidity of the Croton water would be removed by aëration to the extent of 50 to 75%. The Water Department and its expert advisers stated the facts of no removal on May 20, but here also Mr. Mitchel seems to have been guided by those who were not correctly informed as to the facts.

GEORGE W. FULLER.

170 Broadway, New York City, June 2, 1913.

Sir—My attention has been called to a letter addressed to you under date of May 26, by J. O. Hammitt, Secretary Citizens Union, in which certain statements are made with reference to my advocacy on the witness stand of the hypochlorite treatment of the water-supply of Jersey City.

In the Jersey City case the question of filtration of the supply was not the point at issue, the physical character of the water being considered satisfactory. The main question was whether or not the hypochlorite treatment would destroy such objectionable bacteria as the water might at times contain. My testimony, which Mr. Hammitt refers to, was given in the early part of 1909, or less than six months after the hypochlorite process was first applied on a practical scale in this country.

The views expressed by me on the witness stand at that time were based on the facts then available as to the efficiency of the process. Subsequent studies disclosed limitations of the process which were entirely unthought of in 1909, and these limitations have been repeatedly set forth by me in various publications and on the witness stand since that time. In an address made before the Annual Convention of the American Public Health Association, held in Milwaukee in September, 1910, I presented in considerable detail all of the evidence available at that time on the efficiency of this process, and paid particular attention to its limitations, closing my address with the following remarks:

LIMITATIONS OF THE PROCESS

In making a complete analysis of the practicability of this process, it is necessary to recognize the fact that it is not possible by the use of this germicide to overcome certain disadvantages, such as the following, which do not appear in connection with certain styles of water treatment:

(1) Inability to remove or destroy all of the spore-forming bacteria not considered to be pathogenic to man, at least not those common to water.

(2) Inability to remove bacteria which are embedded in particles of suspended matter.

(3) Inability to remove turbidity.

(4) Inability to remove appreciable amounts of color or dissolved vegetable stain.

(5) Inability appreciably to remove organic matter.

(6) Inability to remove swamp tastes or odors.

(7) Inability to remove creosote tastes or odors coming from the cleaning of stills used in the destructive distillation of wood.

(8) Inability to soften water; as a matter of fact, the addition of hypochlorite of lime usually results in a slight increase in the hardness of the water—although this is not ordinarily measurable—notwithstanding the fact that the commercial product usually contains a little free quicklime which reduces slightly the carbonic acid in the water.

(9) Difficulties encountered in applying this process, except with the greatest care, to waters which contain substantial quantities of reducing agents or compounds capable of oxidation, such as nitrites and unoxidized iron.

The foregoing statements set forth the advantages and shortcomings of this process which, like other things that are new, is likely to be, and in some cases is, considered a cure-all for all water ills, no doubt with disappointing results in some cases.

The application of hypochlorite to water, while comparatively simple, should always be carried out with much care and fidelity by a competent analyst; otherwise, if the dose is not adjusted so as to meet satisfactorily all local conditions, there is liable to be alternately an overdose of the chemical insufficient to sterilize, or an overdose which will result in objectionable tastes and odors readily noticeable to the consumers, and due to the bleach itself.

The use of hypochlorites cannot be considered in the light of a substitute for filtration. Where waters are uniformly satisfactory in appearance, but open to suspicion as regards their content in bacteria, the use of the hypochlorite process alone in many cases may prove sufficient. Where waters are unsatisfactory in physical appearance and are also polluted and require filtration, the combined use of filters and the hypochlorite process is called for. As an adjunct to filtration processes it has a distinct field of applicability, as above stated, for at a moderate cost it is feasible to obtain a water which is practically above suspicion; and, further-

more, there is brought about a substantial economy in the first cost of the filtration plant. This is made possible by the use of higher rates of filtration than are ordinarily used, and the required filter area may therefore be reduced. It also effects a substantial economy in the cost of operation.

It is not true, therefore, as Mr. Hammitt would have it appear, that I have suddenly taken a new position with reference to the hypochlorite treatment. As fast as I secured new information referring to the limitations of the process I promptly made it public, and the statements made by me at the hearing in President Mitchel's office were precisely those I have been setting forth publicly for at least three years. Those who have heard my remarks can by reference to the above quoted article, satisfy themselves that I expressed no views contrary to those I have held for several years.

In testimony given by me last March, in the case of the People of the State of New York vs. Passaic Valley Sewerage Commissioners, I made it very plain that while in 1909 the hypochlorite treatment gave every promise of complete success in the sterilization of the Jersey City water-supply, subsequent studies made by me for the Board of Street & Water Commissioners of Jersey City have shown that owing to the steadily increasing pollution of the supply it has become necessary to materially increase the dose of germicide. Furthermore, I expressed the conviction that the day is not far distant when the hypochlorite treatment will have to be abandoned there, for the reason that to kill the objectionable germs such large doses of the chemical will be required as to impart offensive and utterly inadmissable taste and odor to the water.

In conclusion I take this opportunity to state that I stand absolutely on what I said at the hearing in President Mitchel's office, and again assert that sterilization of the Croton water-supply is not to be considered in the light of a substitute for filtration in any sense except that an uncertain proportion of the pathogenic germs will be destroyed by its use. It is not a complete treatment, and the Croton supply can never be considered satisfactory until it is filtered.

All of the facts above set forth must have been in the possession of Mr. Hammitt when he wrote his letter to you, and to support his own imperfect claims he has used only such information as I possessed over four years ago, and has not seen fit to give any consideration to the various articles on the hypochlorite treatment I have published since that time:

GEO. A. JOHNSON.

150 Nassau St., New York City, June 2, 1913.

NOTES AND QUERIES

Azimuth by Direct Solar Observation—A correspondent in Vermillion, S. D., J. Maughs Brown, calls our attention to an error in the formula for determining the error in azimuth due to a one-minute error in latitude, which occurs twice in the article on "Azimuth by Direct Solar Observation," by Louis Ross, in our issue of Mar. 6, pp. 455 and 456. The formula given as $\frac{dZ}{dL} = \sec L \cos t$ should read $\frac{dZ}{dL} = \sec L \cot t$. The table given below the formula is correctly computed. Our correspondent also suggests that the diagram shown in Fig. 6, p. 455, for finding the approximate time could very nicely be supplemented by a diagram for the equation of time placed directly underneath.

In noting the establishment of the Mellon Institute of Industrial Research and School of Specific Industries at the University of Pittsburgh, in our issue of Apr. 17, 1913, p. 790, we gave credit to Henry Hornbostel, of Pittsburgh, as the architect of the Institute building. We are informed that the statement from the University on which this note was based was in error in that the architect is J. H. Giesey, of Pittsburgh, and that Mr. Hornbostel's connection is only in a consulting capacity as the architect of the existing university buildings.

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Oiling Grade Crossings so as to prevent a dust nuisance is being regularly practiced on the Delaware, Lackawanna & Western R.R. Two equipments are in use in different parts of the line, each consisting of an oil car provided with compressed-air tanks and special nozzles for spraying the oil. These cars are drawn along the line, and the crossings are oiled in succession by a crew that goes with the car, so that each crossing is oiled about twice each year. It has been found that this procedure is successful in keeping down the dust to such an extent that there is no offense from that source to passengers, particularly to those on rear-end observation cars, where before the oiling the nuisance had been great.

A Photometric Laboratory on Wheels has been equipped by Hollis Godfrey, in charge of the Philadelphia Bureau of Gas under Morris L. Cooke, Director of Public Works. Trouble had been experienced in keeping the candlepower of street lamps up to the contract figure, and, as the contractors objected to photometric tests with small portable apparatus, standard laboratory equipment was mounted on a covered motor truck to be carried about the city and used to study the lamps burning in place, but with apparatus and under conditions prevailing in a good laboratory. So far only the gasoline lamps have been reported on; in four months, the penalties for outages and insufficient candlepower on these 19,000 lamps amounted to $41,036. The Gas Bureau has jurisdiction also over 14,000 electric and 24,000 gas lamps, and it is expected that these will be studied in their turn.

The Danger from Electric Shock in directing a stream of water on a high-tension electric line is discussed by F. C. Caldwell, Professor of Electrical Engineering at the Ohio State University, in the "Sibley Journal of Engineering" (Cornell University undergraduate publication). Measurements of resistance of a stream of water between the hose nozzle and a 12-ft. piece of No. 6 copper wire were made. Voltage was obtained from a 250,000-volt 50-kw. transformer, with the middle point connected by a low reading ammeter to earth and one terminal connected to the wire. Variation of frequency between 45 and 60 cycles with 20,000 volts showed no appreciable reactance of the stream and resistance was then calculated from current and voltage readings.

Increase of water pressure gave increased resistance of stream. This increase was slight for 6- to 10-ft. lengths of streams, but was marked for 15 ft.; the higher pressures gave a less solid stream, especially at greater distances from the nozzle. With a 1⅛-in. nozzle for 5000 and 30,000 volts the resistance gradually increased up to a critical length, which was about 17 ft. for a 1⅛-in. nozzle and 20 ft. for a 1½-in. Beyond this point the resistance rose suddenly and approached infinity. The critical point was where the stream ceased to be continuous and broke up into a mass of separate water drops. With a stream length of 15 ft. on a 50,000 volt wire, a resistance of about 20,000 ohms water path would be obtained and a current of about 0.25 amp. This would give the holder of the nozzle a severe shock and might be dangerous. With a stream length of 20 ft. for a 1⅛-in. nozzle, or 25 ft. for a 1½-in. nozzle the resistance would be 800,000 ohms or more, which would give but 0.06 amp. or less. This might be painful but practically not dangerous. The resistance of the body, being only a few thousand ohms, has been neglected in that statement. It is believed that such high-tension circuits when near buildings would be more than 25 ft. from the ground, so that there is little fear of injury to firemen from this source.

The fact that a nozzle is grounded through the stream of water in the hose was studied, but not found to keep the voltage so near that of the earth that danger to the nozzle holder was eliminated. Resistance of the path from nozzle to ground, through the water in the hose when the latter was thoroughly insulated, was found to be about 150,000 ohms per 100 ft., which could not be depended upon to shunt much of the current around a man holding the nozzle.

A similar study of dangers from playing streams on trolley wires was studied by the Pennsylvania R.R., as noted in "Engineering News," Nov. 19, 1908, p. 569. The results were in general agreement with the foregoing.

The Failure of the Sand Canyon Pressure-Tunnel Siphon of the Los Angeles Aqueduct

By Burt A. Heinly*

In Engineering News of May 29, announcement was made of the failure of the Sand Cañon siphon of the Los Angeles Aqueduct and the postponement until some time in October of the dedication of the project which was to have taken place June 19-20.

The failure of the work which in this instance was *pressure tunnel* and which in no way should be associated with the inverted steel siphons of the Aqueduct which have been tested and found satisfactory, makes necessary the building of a new siphon entirely of steel across the cañon. The replacement of the damaged section involves an expenditure of approximately $40,000, or about one-sixth of one per cent. of the cost of the whole Aqueduct work, and a delay of ninety days.

The break occurred on the morning of May 19 at a point 100 miles below the Aqueduct intake and 150 miles north of the city. The interruption of flow is therefore 32 miles below the Haiwee Reservoir so that the filling of that impounding basin with a capacity of 63,800 acre-feet, which was begun Feb. 9, continues without hindrance. Moreover, as the city trunk line from the outlet of the Aqueduct to the city's distribution system is just entering upon construction, and as the city will be able to tide over the summer with its present water-supply, the failure, while causing some expense and creating disappointment at the postponement of the dedication, creates no difficulties that will prove onerous.

The breakage was due to a form of construction which, while recommended wherever ledge rock occurred at sites of siphon crossings, was adopted only at Sand Cañon, where the rock was sounder than at any other point on the Aqueduct.

The siphon as built has a total length of 2788 ft., consisting of 639 ft. of pressure tunnel 9 ft. 2 in. in diameter down the north side of the cañon on an incline of 45°, 597 ft. of horizontal pressure tunnel of the same diameter with 10 ft. of transition connecting to 890 ft. of steel pipe 8 ft. 6 in. in diameter of $\frac{11}{16}$-in. steel, then 30 ft. of horizontal pressure tunnel (including 10 ft. of transition) of 9 ft. 2 in. diameter connecting with a pressure tunnel of the same diameter, 632 ft. in length and at a 45° incline up the south wall of the cañon. Where the steel pipe crosses the surface bed of the cañon it rests on concrete piers and at this point is 455 ft. below the hydraulic grade of the Aqueduct.

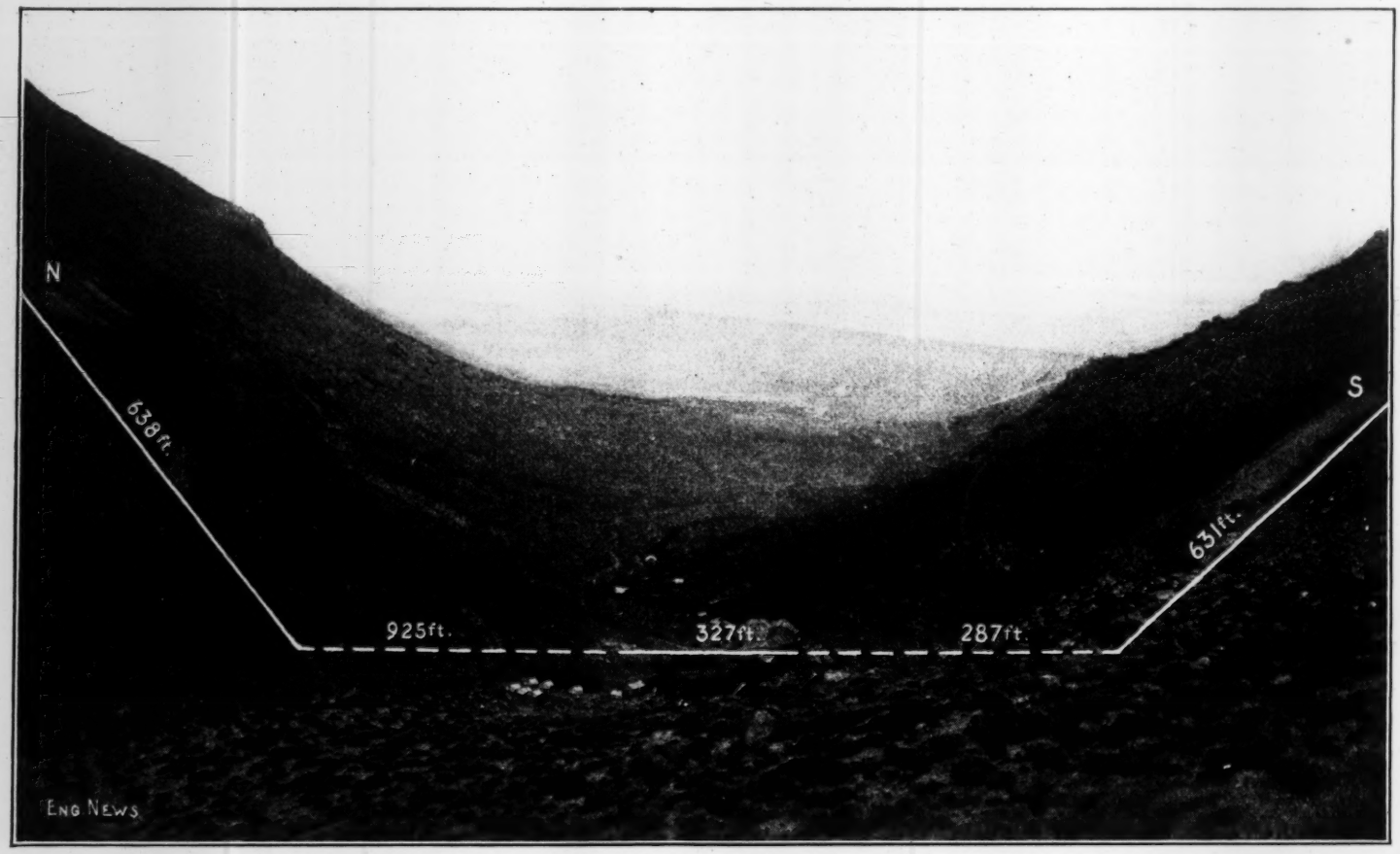

Fig. 1. General View of Site of Sand Cañon Tunnel Siphon, Los Angeles, Calif.; Looking East

(The white line shows the original survey location of the siphon. After construction changes were made, which slightly modified the figures printed on the view, as may be seen by reference to the profile, Fig. 2. A comparison of this view with Fig. 3 will show the change made in the aspect of the south side of the cañon by the slide that followed the failure of the siphon.)

The construction was in massive granite apparently sound and of great hardness and durability, as is shown by the fact that where on an average the tunnels of the Aqueduct required from 25 to 30 lb. of 80% gelatin powder to the foot for breaking, on these pressure tunnels an average of 40 lb. was required. At the transitions there is 81 ft. of cover on the north side and 160 ft. on the south side, while the minimum depth of cover on the tunnels was 70 ft., with 170 ft. as the maximum.

The concrete lining averages 12 in. in thickness and

*636 South Hill St., Los Angeles, Calif.

is of 1:2:4 mix. On the horizontal tunneling, the concrete was grouted under 200 lb. pressure while on the inclined tunnels it was poured from the top.

The tunnel work was completed before July, 1912. The concreting was begun in August and was completed in October. Fabrication of the steel was completed in November but testing of the whole structure was delayed until a sufficient supply of water could be obtained by the operation of the Aqueduct.

On May 13, 1913, this testing was undertaken. Quickly following the turning in of the water, the pressure tunnel on the north side, 50 ft. from the end of the steel, showed weakness with a blowout following, and the siphon was drained.

The Department of Public Service had steel arriving for the construction of the City Trunk Line and, with certain modifications at local foundries, within 48 hours had started to its destination the material necessary for repairs. This consisted of 345 ft. of 66-in. diameter, 3/8-in. pipe, which was placed as shown in Fig. 2.

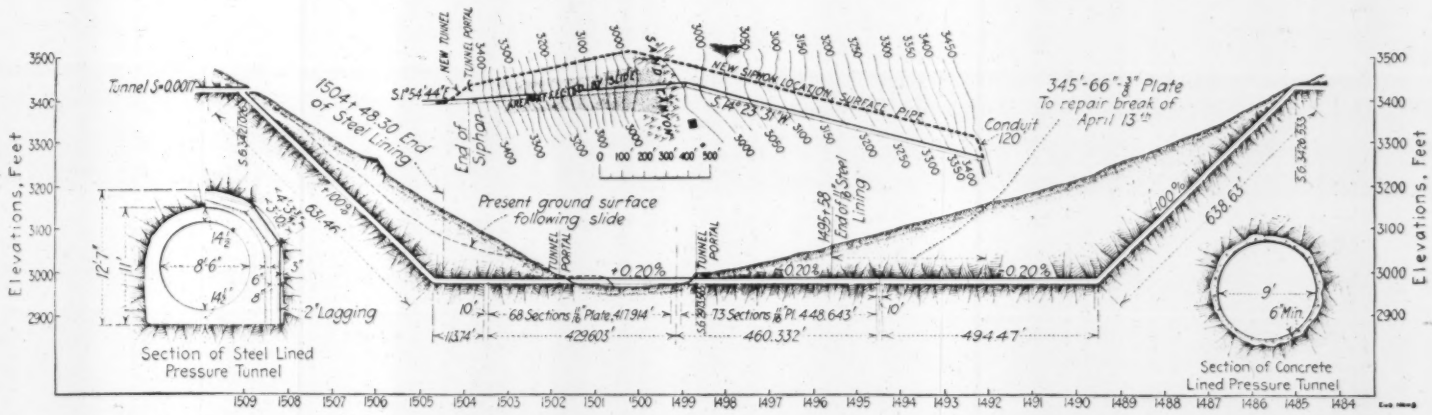

FIG. 2. PLAN, PROFILE AND SECTIONS OF SAND CAÑON TUNNEL SIPHON, LOS ANGELES AQUEDUCT, SHOWING LOCATION OF FAILURE, OF SLIDE AND OF NEW STEEL SIPHON

(All distances and stations refer to bottom of pipe. Sub Grade, "S. G.," is taken as finished line of concrete in bottom of invert and the bottom of the pipe. The hydraulic properties are: Diameter of pipe, 8½ ft.; area, 56.745 ft.; perimeter, 26.704 ft.; hydraulic radius, 2.125 ft.; "C" in Chezy's formula, 90; hydraulic slope, 0.00334; capacity, 430 sec.-ft.; velocity, 7.58 ft. per sec.)

On May 16, the final testing of the siphon was undertaken by turning in 17 sec.-ft. In passing, reference to the north side may be dismissed by stating that with the exception of a small and unimportant leak it showed sound. The south side, however, within fifteen minutes after the water had reached hydraulic grade, began to show signs of failure about 125 ft. from the top. The three 16-in. Rensselaer blowoff gates at the lowest point

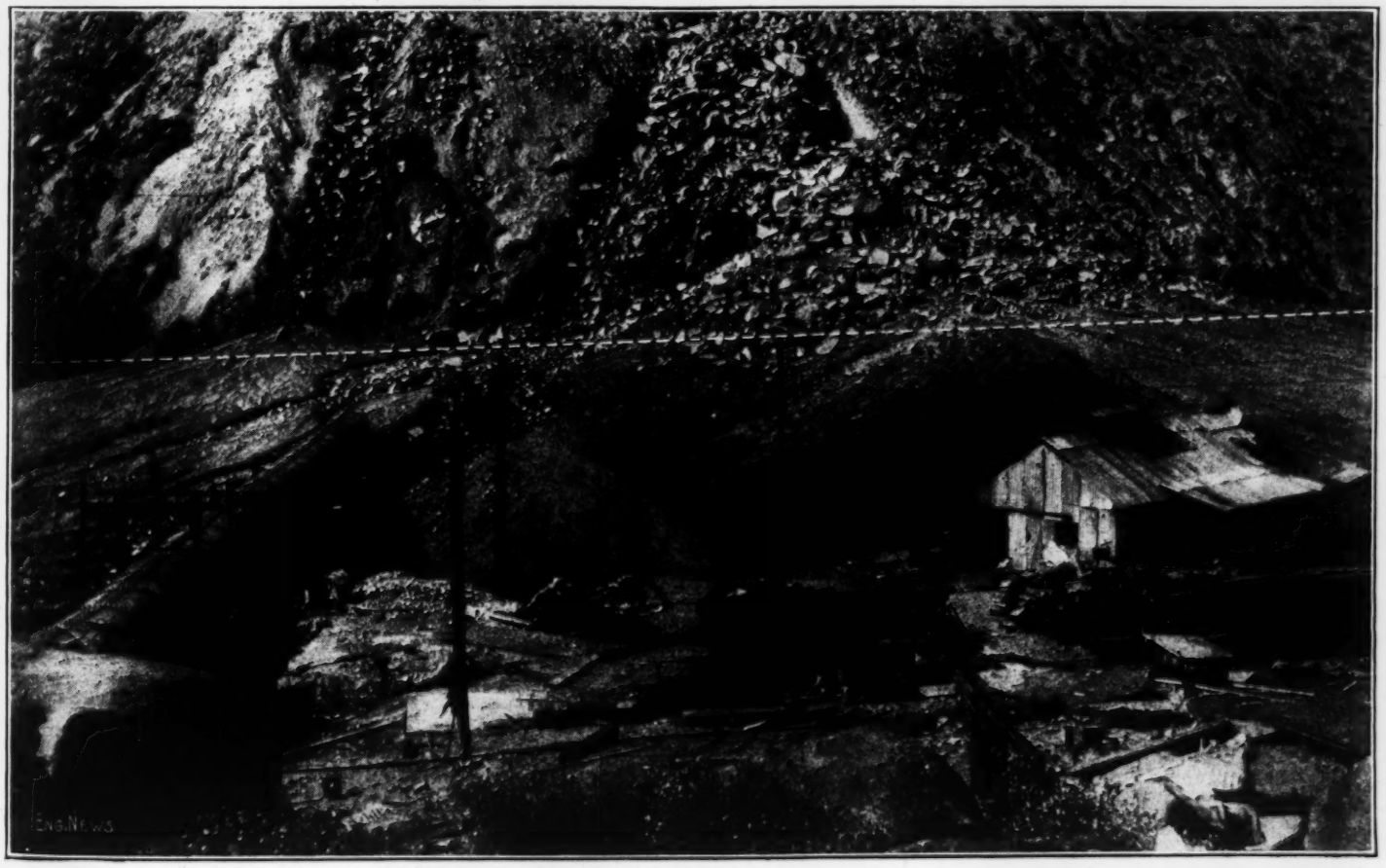

FIG. 3. BASE OF SLIDE AT SAND CAÑON PRESSURE SIPHON, LOS ANGELES AQUEDUCT

(From photograph taken at 9 a.m., Monday, May 19, following failure of South Pressure Tunnel. The line drawn across the view gives an idea of the yardage that slid, or washed into the bottom of the cañon; see also Fig. 2.)

in the siphon were immediately opened and the siphon drained.

Investigation showed that from a point about 125 ft. from the top to 150 ft. of the bottom of the incline, the concrete gave evidences of ultimate failure of the structure.

With the determination to test it to either the full flow of the Aqueduct or to destruction, on Sunday night the gates of the Haiwee Reservoir were opened to admit a flow of 42 sec.-ft. This flow had reached and filled the siphon by 6 a.m., Monday. Between that hour and 7 a.m., the displacement of the whole side of the cañon wall took place with the rupture of the tunnel for several hundred feet. The bulk of the water burst forth and with the accompanying movement of the saturated covering of the tunnel, a very large quantity of débris was carried to the floor of the cañon, as is shown in Figs. 2 and 3.

An examination of the tunnel showed checks and openings in the concrete ranging from the thickness of a knife blade to 3 in. and extending from within 125 ft. of the top to within 150 ft. of the bottom.

The examination disclosed no faulty construction. It should be noted that this was force account work in which there was no object in shirking or in the use of faulty materials. Indeed, on the contrary, because of some doubt expressed by the chief engineer at the outset as to the feasibility of pressure-tunnel construction, the work was carried on with more than usual care by the field construction force, with a very liberal use of cement. The quality of materials and the character of the workmanship is, therefore, not open to question by Aqueduct heads.

The plans for reconstruction call for the rebuilding of a new siphon entirely of steel from 100 ft. to 150 ft. west of the present pressure tunnel, as shown in Fig. 2. Within 72 hours after the break, plans for the new siphon had been prepared, bids received by telegraph and the contract awarded to the Riter-Conley Manufacturing Co. for 463 tons of steel plate, rolled, punched and sheared in accordance with the standards of Aqueduct siphon construction, delivery to be completed at Leetsvale, Penn., within 35 days. The 890 ft. of 8½-ft. pipe held taut and true through the bombardment of huge boulders that accompanied the break and it will be only necessary to move it to its new location. The siphon as now designed will consist of 1662 ft. of ¼- to ⅝-in. plate, 10 ft. in diameter, tapering to 8½ ft., with triple-riveted longitudinal joints and single-riveted circumferential joints.

The full construction equipment remains on the ground and with the exception of some changes in location of the hoists is ready for service. It is planned that the new work shall be completed within the next ninety days, and the expectation is that the whole system will be placed in operation shortly after that time.

No date has been definitely set for the dedication of the work but invitations will be mailed by the Celebration Committee to engineers throughout the country, government and state officials within two or three weeks or as soon as the dates are definitely determined.

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The Time for Completing the Cape Cod Canal has been extended to June 3, 1915, by an order of the Massachusetts Harbor and Land and Railroad Commissions, issued on Apr. 25.

United States Cement Statistics for 1912

Cement production in the United States for 1912 has been reported by E. F. Burchard, the U. S. Geological Survey expert, as follows:

PRODUCTION

The total quantity of portland, natural and puzzolan cements produced in the United States in 1912 was 83,351,191 bbl., valued at $67,461,513, compared with 79,547,958 bbl., valued at $66,705,136, in 1911. This represents an increase in quantity of 3,803,233 bbl., or 4.78%, and in value of $756,377, or 1.13%.

The distribution of the total production among the three main classes of cement in 1912 is as follows: portland, 82,438,096 bbl., valued at $67,016,928; natural, 821,231 bbl. valued at $367,222; puzzolan, 91,864 bbl., valued at $77,363.

The total production of portland cement in the United States in 1912, was 82,438,096 bbl., valued at $67,016,928, compared with 78,528,637 bbl., valued at $66,248,817, in 1911. The output for 1912 represents an increase in quantity of 3,909,459 bbl., or nearly 4.98%, and in value of $768,111, or 1.13%.

The shipments of portland cement from the mills in the United States in 1912 are 85,012,556 bbl., valued at $69,109,800, compared with 75,547,829 bbl., valued at $63,762,638, shipped in 1911. The shipments therefore represent an increase in quantity of 9,464,727 bbl., or 12.52%, and in value of $5,347,162, or 8.38%. The average price per barrel in 1912, according to these figures, was a trifle less than 81.3c., compared with 84.4c. in 1911. This represents the value of cement in bulk at the mills, including labor and costs of packing, but not the value of the sacks or barrels. The average price per barrel for the country is about 13.9c. higher than the average price received for portland cement in the Lehigh district, where it was sold at the cheapest rate, and is near the average price received in the Iowa-Missouri district, but it falls 54.5c. below the average price received on the Pacific coast, where portland cement brought the highest figure during the year.

STOCKS ON HAND

Reports were received from nearly all the mills in the United States that shipped any portland cement in 1912, giving stocks of finished cement on hand Dec. 31, 1912. For the very few mills which did not report this information an estimate, believed to be very close, has been made. The apparent stock on hand at the end of 1912 amounted to 7,811,329 bbl., compared with 10,385,789 bbl. on hand at the close of 1911, according to reports and revised estimates, thus indicating a reduction in stock of more than 2,500,000 bbl. during 1912.

IMPORTS OF FOREIGN CEMENT

The imports and exports of cement are reported to the Survey by the Bureau of Foreign and Domestic Commerce. The statements include all hydraulic cements, also the weights of sacks or barrels. Portland cement probably makes up at least 95% of the total in each year.

The imports of hydraulic cement in 1912 were approximately 68,503 bbl., valued at $93,558, or about $1.37 a barrel, compared with 164,670 bbl., valued at $242,722, or $1.47 a barrel, in 1911. This decrease in the quantity of cement imported was to be expected in view of the large excess domestic stocks that were marketed at low prices during the year.

EXPORTS

The United States has a comparatively small export trade in cement. In 1912 the quantity exported was only 4,215,532 bbl., most of which was portland cement, valued at $6,160,341, or approximately $1.46 a barrel, compared with 3,135,409 bbl., valued at $4,632,215, or about $1.477 a barrel, in 1911. The quantity exported in 1912 was slightly more than 5% of the total production of hydraulic cements in 1912. The exports in 1910, 1911 and 1912 have shown increases of 135, 27 and 26% respectively, over those of the preceding year.

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Cable Street Railways are still in use in the city of Edinburgh, Scotland. It is probable that this is the only city in the world where the cable system for ordinary street railway traffic, which was so extensively introduced twenty-five years ago, still remains in active service. It is recognized in Edinburgh, however, that extensions to the present cable system are not advisable. In view of the demand for new lines to suburbs, the City Council of Edinburgh has appointed a committee to visit a number of English cities and examine various types of street railways. It should be understood that the Edinburgh street railways are owned and operated by the city.

A Lower Court Decision on a Concrete Dam Patent

The following decision has been rendered by Justice Holt in the United States District Court, Southern District of New York, in the case of the Ambursen Hydraulc Construction Co., complainant, against the Hydraulic Properties Co., defendant. The Ambursen Hydraulic Construction Co. has taken an appeal from this decision of the lower court.

HOLT, J.:

This is a suit to enjoin the alleged infringement of a reissued patent, No. 12,246, granted July 26, 1904, to Nils Frederick Ambursen, for certain improvements in dams. Claims 2 and 3 of the patent are relied on. They are as follows:

2. A dam comprising a base, an inclined concrete flooring overhanging the base, a plurality of spaced buttresses interposed between the base and flooring, and metallic reinforcing members embedded in the flooring and extending lengthwise thereof and across the buttresses.

3. A dam comprising a base, spaced buttresses rising therefrom, and a relatively thin inclined concrete flooring supported by and overhanging the buttresses and base, said flooring having metallic reinforcing members extending lengthwise of the flooring and across the buttresses.

There is nothing novel in either of these claims except the use of concrete in the construction of the flooring. Before the use of concrete dams were made of timber, iron or steel, or of solid masonry. The complainant's concrete dam is substantially a reproduction in concrete of an old and familiar style of timber dam. The flooring is supported by buttresses with spaces between. The solid masonry dam had become, before the introduction of the concrete dam, the standard form of dam for the retention of large reservoirs of water.

The complainant's concrete dam is claimed to have, and I am satisfied from the evidence that it has, various points of superiority over the solid masonry dam. The cost is low. The material is plastic. It forms a solid mass without joints. But that is a feature of all concrete construction. The great development of the use of concrete in recent years has made it a valuable building material for many purposes. Its use alone, or reinforced by iron or steel rods or wires, was well known in other forms of construction when the first concrete dam was built. It was natural that it should have been tried late in dam building because of the great danger arising from any insecurity in a dam; but it seems to me that it was certain, in the development of the use of concrete, to be ultimately used in dam building.

The description and drawing in the original and reissued patent shows a dam with a curved flooring, and great stress is laid, in the descriptions and claims, on the importance of the curved flooring as causing the lines of pressure, perpendicular to the face of the flooring, to lie wholly within the limits of the base of the buttresses. No such dam has been built. All that have been built have a straight flooring. It is claimed that the patent applies to dams with a straight flooring, and, if it were valid in other respects, I think it would apply to them. The patent also describes and claims a method of fastening the buttresses to the base. But no claim is made in this case that the defendant threatens infringement of the curved flooring or of the method of fastening the buttresses described and claimed in the patent.

The claim is that under this patent the complainant has a monopoly of dams made of concrete after an old style of wooden dams. The general rule is, of course, that the substitution of one material for another is not invention. Undoubtedly the complainant's forms of concrete dam has many advantages; but they seem to me to result simply from the natural qualities of concrete, and not from any newly discovered qualities. The use of concrete for dams has the usual advantages that it has for houses and bridges, and for many other forms of construction. But that does not make its first adoption for a particular use patentable. If this patent is valid the first maker of a concrete house or bridge or sidewalk was entitled to a patent for the thing made.

The bill is dismissed, with costs.

May 27, 1913.

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A Reduction in Express Rates in Wisconsin averaging 20% has been ordered by the Railroad Commission of that state.

Forest Trees Around the Water-Works Reservoir of Hornell, N. Y., will be planted by the Board of Public Works of that city in coöperation with the College of Forestry, of Syracuse University. It is stated that about 30,000 trees will be planted.

NOTES FROM THE ENGINEERING SCHOOLS

COLUMBIA UNIVERSITY—The sum of $20,000 has been placed at the disposal of the department of electro-mechanics by an anonymous contributor. This has been used for equipment to carry on research work in the joint field of physics and electrical engineering, under the direction of M. I. Pupin. The department occupies the basement of the Philosophy Building. Here several rooms are fitted up, well lighted and furnished at present as work rooms for research students. There are the office of the director, two large laboratories and two smaller rooms, a machine shop, a lecture room and a photographic dark room. Each laboratory has a switchboard panel from which 110 or 220 direct current and 60-cycle alternating current can be drawn. In addition there are now in service several small motor-generator sets mounted so as to be moved easily from room to room. Currents may be obtained of any frequency from a few cycles up to 200,000 per second. There is a large equipment of oscillographs, galvanometers, hot-wire indicating instruments and miscellaneous electrical instruments.

RENSSELAER POLYTECHNIC INSTITUTE—The Board of Trustees has decided to offer a Master's degree in science and engineering for one year's graduate work, and also the degrees of Doctor of Science and Doctor of Engineering for three years' graduate work, of which at least two years must be in residence at the Institute. The courses leading to these degrees are for college graduates whose previous courses fit them for the proposed work. Both laboratory research and theoretical study are to be required.

A four-year course in chemical engineering (leading to the degree chemical engineer) has been established. The first two years are similar to those of the older engineering courses, while the last two years contain more chemistry and particularly more industrial chemistry than the other courses.

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A Survey of the Proposed Delaware River Drive from Trenton to Cape May, N. J., following so far as possible the Delaware River, was authorized by the New Jersey Legislature of 1913, and an appropriation of $15,000 was made for the purpose.

Enlarged Powers Granted to the Municipalities of New Jersey by the legislature of 1913 included the following: City planning commissions may be appointed by cities of the second class (first-class cities already have that power), to be composed of not more than nine members who are to have a yearly appropriation of $5000 for their work; cities may build public docks; cities may hold annual exhibits of the work accomplished by their different city departments; local boards of health were given the same power as the State Board of Health in the regulation of foods.

Plans for a Freight Terminal for the Pennsylvania R.R. Co., at Baltimore, were outlined by President Rea, on May 29. The company proposes to erect a large freight terminal there and will give the city 30 ft. of its Calvert St. property, one block in length, for the purpose of widening that street in order to provide access to the proposed freight houses. In return it expects the city to deed to it adjacent sections of the following streets: Centre, Monument, Madison, Read, Davis, Halliday, Franklin, Bell and Courtland Alleys. It is intimated by the "Baltimore Sun," of May 30, that future freight-terminal developments by the Pennsylvania in Baltimore will aggregate $10,000,000; but the present plan involves only the erection of the one on Calvert St. for which property to the value of approximately $1,000,000 has already been acquired.

An Explosion in the Engine Room of the destroyer "Stewart" during a speed test on May 23, 28 miles off San Diego, Calif., resulted in the death of two men and the serious injury of a third.

Some Dynamite Accidentally Exploded on May 22, killing four men and seriously injuring a fifth, who were employed in construction work on the Southern Pacific Ry., at Iceland, near Truckee, Calif. It is stated that the explosion resulted from the accidental setting off of a box of caps which ignited the dynamite.

A Locomotive Jumped the Track and plunged 18 ft. to the bed of a coal pier of the Pennsylvania R.R., at Baltimore, Md., on May 26, killing the fireman. The locomotive and the tender turned over in the fall from the trestle but none of the empty coal cars which it was drawing left the track. It is thought that a defective flange on one of the wheels of the locomotive caused the accident.

The Collapse of an Unused Coal Hoist of the old Frederick Teves Coal Co., near the foot of North First St., Brooklyn, N. Y., on May 29, caused the injury of five men. The structure was undergoing demolition by a wrecking company at the time of the accident.

Fifty Tons of White Lead Crashed Through Four Floors of the five-story building of the American Ice Co., at Philadelphia, May 24. The upper floors of the building were used by the Lawrence McFadden Co., a paint and varnish concern. The falling lead tore down the water and gas pipes and five of the rescuers were overcome by the escaping gas. The section of the street on which the building fronts has been closed.

A Premature Dynamite Explosion killed three men and seriously injured three others who were employed by the Dominion Construction Co. The gang was clearing the way for the construction of a spur line from the Canadian Pacific Ry. to the Lehigh Cement Co., near Bellville, Ont., Canada. It is stated that the accident was the result of the rapid progress of the charging, the dynamite being placed in the holes before they were allowed to cool after being drilled.

The New Union Station at Chicago is a subject of controversy as to its proposed location. As planned, it is to occupy practically its present site, west of the river, but covering a much larger area and extending from the river west to Clinton St., and from Jackson Boulevard north to Adams St. It will be a double-end terminal, with two railways entering from the north and two from the south, and would have 11 tracks for the former and 15 for the latter. The tracks would be 12 ft. below the street level at Clinton St., owing to the slope of the ground west from the river. Some interests, however, are advertising a location farther south, near 12th St., either as part of one immense railway station, or as one of a group of terminal stations, the latter plan being that advocated by F. A. Delano, President of the Wabash R.R. The matter is now being considered by a committee of the City Council, and public hearings have been held to get the views of railway authorities, civic and commercial associations and other interests.

The Government Department of Public Works suggested by Ishom Randolph and advocated at the recnet convention of the National Drainage Congress, was referred to substantially as follows in the resolutions adopted at that covention, to be presented to the President and to Congress:

We believe it to be a proper function of the Government of the United States, under the welfare clause of the Constitution, to take adequate measures to control the flood waters of our country, and so to conserve them as to protect the life, health and property of our citizens. This is a governmental duty equally as imperative as that of protecting our citizens from the attack of a foreign foe.

We petition the immediate consideration of adequate provisions for flood control, for the regulation and control of stream flow, and for the reclamation of swamp and overflow lands and arid lands. We believe the most effectual and direct means will be the establishment of a Department of Public Works, with a Secretary in charge thereof, who shall be a member of the President's cabinet.

We further believe that the wide scope of the problem of flood-water control, affecting practically all the states of the Union, can best be conducted under the immediate supervision of the President of the United States.

Geologic Folio and Atlases at Low Cost may be had from the U. S. Geological Survey at Washington, D. C., as a result of the recent fire at headquarters ("Engineering News," May 22, 1913, p. 1098). The following announcement has been made:

The entire basement, in which the geologic folios were stored, was filled with dense smoke and many of the folios were burned, others scorched, and all more or less damaged by water. With the approval of Secretary Lane the Director announces that he will sell the entire remaining stock of some 150,000 folios, four-fifths of which are probably as near perfect as goods usually offered in a smoke or fire sale, at the nominal price of 5c. each. The regular retail price of the standard folios is 25c., but a few unusually large folios have sold for 50c., and the regular price of the "field edition" of the later folios, a more convenient form for use in the field, is 50c. All these are now to be had at 5c. each, but no wholesale rate applies to this fire sale.

Now is the time for students, engineers, and the public generally to order geologic folios to complete their files or to become acquainted with this Government publication, the 188 numbers of which fully describe the geology of some 175,000 sq.mi. of the United States. The stock includes probably 50,000 to 100,000 copies on which the real damage is practically negligible. Application should be made to the Director, U. S. Geological Survey, Washington, D. C., and remittance made by money order or in coin. Lists will be sent on application.

PERSONALS

Mr. Frank W. Buffum, of Louisiana, has been appointed State Highway Commissioner of Missouri at a salary of $3000 per annum.

Mr. Joseph E. Davies, a lawyer of Madison, Wis., has been appointed Commissioner of Corporations, United States Department of Commerce.

Mr. James D. Beaver, formerly Assistant Trainmaster, has been promoted to be Assistant Superintendent of the Pittsburgh, Shawmut & Northern R.R., at St. Marys, Penn.

Mr. James H. Sturdevant, Assoc. M. Am. Soc. C. E., Deputy Superintendent of Highways, New York State, was married on May 31, to Miss Mary P. Holmes, of Summit, N. J.

Mr. A. H. Wheatley, Assistant to the President of the Alaska Northern Ry., has resigned, and the duties of his office will be assumed by Mr. A. W. Swanitz, Chief Engineer.

Mr. H. A. Mentz has been appointed Engineer in charge of the newly opened branch office of the Solomon-Norcross Co., Consulting Engineers, in the Randolph Bldg., Memphis, Tenn.

Mr. Charles Hansel, M. Am. Soc. C. E., Consulting Engineer, of 43 Wall St., New York City, has resigned as Chief Engineer of the Cincinnati Union Depot & Terminal Co., Cincinnati, Ohio.

Mr. R. H. Dwyer, former Division Superintendent of the Missouri Pacific Ry., at Pueblo, Colo., has been appointed Superintendent of Construction of the Tela R.R., with office at Tela, Honduras.

Mr. W. S. Burnett has been appointed District Engineer in charge of construction on the Cleveland-Indianapolis and Cincinnati-Sandusky divisions of the Cleveland, Cincinnati, Chicago & St. Louis Ry., with headquarters at Middletown, Ohio.

Mr. A. M. Turner, Assoc. M. Am. Soc. C. E., formerly Resident Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., at Beach Grove, Ind., has been promoted to be District Engineer in charge of construction on the Chicago, St. Louis, Cairo and Michigan divisions.

Mr. P. J. Carter, who resigned as Office Engineer of the Gulf, Colorado & Santa Fé Ry., at Galveston, Tex., to engage in post-graduate work at the University of Wisconsin, has recently been appointed Office Engineer of the Western Lines of the Atchison, Topeka & Santa Fé Ry., at Amarillo, Tex.

Mr. Frank Beckwith, M. Am. Soc. C. E., Office Engineer of the Chicago, Burlington & Quincy R.R., Chicago, Ill., is reported to have been selected as Chief Engineer of a division of the new Chinese National Rys., about to be constructed. Mr. Beckwith is a graduate of the University of Illinois and has been in railway work in China before.

Mr. Walter W. Curtis, M. Am. Soc. C. E., Consulting Engineer, Chicago, Ill., has discontinued his Chicago office to take charge as President, of the Curtis Coal Mining Co., Colorado Springs, Colo. He will continue, however, to devote a portion of his time to private engineering practice, with headquarters at 1015 North Nevada Ave., Colorado Springs.

Mr. V. D. Simar has resigned as Chief Engineer of the Duluth, South Shore & Atlantic Ry., which position he has held since 1910. Mr. Simar's engineering experience began in 1870 as a chainman with a location partly on the Chicago, Milwaukee & St. Paul Ry. He was Locating Engineer for many miles of various railways west of the Mississippi River.

Mr. Frank W. Pfleging, formerly Signal Supervisor of the Kansas division of the Union Pacific R.R., Kansas City, Mo., has been promoted to be Signal Engineer, with headquarters at Omaha, Neb., succeeding the late J. C. Young. Mr. Pfleging graduated from Rose Polytechnic Institute in 1901, and has since been with the signal department of the Union Pacific R.R.

Mr. E. C. Carter, M. Am. Soc. C. E., Chief Engineer of the Chicago & Northwestern Ry., has been relieved of the active duties of his office in order that he may devote his whole time to special duties in connection with a physical valuation of the railway's property. Mr. W. H. Finley, M. Am. Soc. C. E., Assistant Chief Engineer, will be Acting Chief Engineer.

Mr. George C. Diehl, M. Am. Soc. C. E., County Engineer of Erie County, at Buffalo, N. Y., has been appointed the third member of the advisory board of engineers to make a thorough investigation of the highway problems of New York State. The other members of the board are Messrs. Harold Parker, M. Am. Soc. C. E., and W. D. Washington, as noted in our issue of May 22.

Mr. Henry Welles Durham, M. Am. Soc. C. E., Chief Engineer of Highways, Borough of Manhattan, New York City, has been appointed by Mayor Gaynor to represent the City of New York as delegate to the International Road Congress to be held in London, England, this month. Mr. Durham has also been delegated to make a study of paving and street maintenance in European cities.

Mr. Frank T. Townsend, Assoc. M. Am. Soc. C. E., recently Assistant Engineer, New York State Highway Department, has been appointed Assistant Engineer of the Inspection Department of the Dunn Wire-Cut-Lug Brick Co., Conneaut, Ohio. Mr. Townsend is a graduate of Rensselaer Polytechnic Institute, class of 1904, and has been with the New York State Highway Department for the past five years.

Messrs. Edwin Thacher and William Mueser, M's. Am. Soc. C. E., announce that they have dissolved the partnership hitherto conducted under the firm name of the Concrete-Steel Engineering Co., 21 Park Row, New York City. Mr. Mueser will continue the business under the former copartnership name, and Mr. Thacher will engage in private practice as a consulting engineer with offices at the same address.

Mr. C. G. Elliott, M. Am. Soc. C. E., has resigned as Chief of Drainage Investigations, United States Department of Agriculture, and will devote his time to private practice. Mr. Elliott has for some time been Chief Drainage Engineer of the John L. Roper Lumber Co., and will continue in this position as well as carry on his consulting work. His office is in the McLachlen Bldg., 10th & G Sts., Washington, D. C.

Mr. F. H. Newell, M. Am. Soc. C. E., Director of the United States Reclamation Service, will hereafter be known as Chairman of the newly created Reclamation Commission, under the reorganization of the Reclamation Service. The commission will consist of five members. Mr. George Barton French will have charge of operation and maintenance; Mr. A. P. Davis, M. Am. Soc. C. E., will be Chief Engineer, as at present, and Judge Will R. King, of Oregon, will be Chief Counsel. Another member of the Commission is to be selected by Secretary of the Interior Lane.

Mr. A. Merritt Taylor has been appointed Director of the new Department of City Transit, Philadelphia, Penn., at a salary of $10,000 per annum. Mr. Taylor has held the office of Transit Commissioner under the Department of Public Works since June of last year, but in this capacity had served, at his own request, without compensation except for personal expenses entailed by his work as Commissioner. He was formerly President of the Philadelphia & West Chester Traction Co. If the present plans for improved transit facilities are carried out it is stated that the new department will require the services of 150 engineering employees.

Mr. E. R. Lewis, Assistant to the General Manager of the Duluth, South Shore & Atlantic Ry., has been appointed Chief Engineer, succeeding Mr. V. D. Simar, resigned, as noted elsewhere. Mr. Lewis was born in Raritan, N. J., in 1869. He graduated from Iowa State University in 1890, and received a C.E. degree there in 1896. His engineering experience began in 1885 as an axman on construction of the Missouri Pacific Ry. He was promoted through various positions in the engineering department until 1896, when he resigned to enter the service of the Mississippi River Commission as Division Engineer on levee construction. The following year he resigned this position and went to South Africa as Locating Engineer for the Cape Government Rys., Cape Colony. Mr. Lewis returned to the United States in 1901 as Engineer in charge of construction of the White River R.R. in Arkansas, later becoming Division Engineer on location and construction of the Fort Smith & Western Ry. in Oklahoma. In 1903 and '04 he was again in South Africa as Locating Engineer for the Cape Colony railways. In 1905-'06 he was Assistant Engineer of the Keweenaw Central R.R., at Hancock, Mich., and then Division Engineer of the Michigan Central R.R. Since June, 1912, he has been Assistant to the General Manager of the Duluth, South Shore & Atlantic Ry

OBITUARY

Mosher A. Sutherland, former City Engineer of Passaic, N. J., died May 16. He was born near Geneva, N. Y., and served in the navy during the Civil War.

Louis Hill, a member of the firm, the E. S. Hill Construction Co., railroad contractors, St. Paul, Minn., was killed by a locomotive on some construction work near Great Falls, Mont., on May 22.

Frank H. Myers, formerly Superintendent of the Chicago, Milwaukee & St. Paul Ry., died at his home in Minneapolis, Minn., on Apr. 8 from apoplexy. He was born in 1876 and began railway work at the age of 15, as a telegraph operator.

Archibald Guthrie, head of the firm of A. Guthrie & Co., railroad contractors, of St. Paul, Minn., died, May 15, in Chicago, Ill. He was 69 years old and had been engaged in railway work since 1866, when he began as a laborer in a track-laying gang on the St. Paul & Pacific R.R. Later he was clerk, brakeman, conductor, purchasing agent and Assistant Superintendent of the St. Paul, Minneapolis & Manitoba Ry. He was a consulting engineer when he became associatd with Foley Bros., railroad contractors. In 1897 he began business for himself under the firm name of A. Guthrie & Co., and also as a member of the firm of Guthrie, McDougall & Co., railroad contractors, of Portland, Ore.

Albert F. Holden, mine manager and owner, died at his home in Cleveland, Ohio, May 8, aged 46 years He graduated from Harvard University in 1888 and took special courses in engineering subjects at the Massachusetts Institute of Technology. Following his school work he went to Utah, where his father had extensive mining interests. Of these properties he was Manager for several years. In 1898-'99 he became associated with Messrs. Clark, Coolidge and Cole, of Boston, Mass., in the organization of the United States Mining Co., which became the nucleus of the present United States Smelting, Refining & Mining Co. He was also extensively interested in Alaska mines. He was owner of the Cleveland "Plain Dealer" and at one time part owner of the Boston "Traveler."

William McMurtrie, a prominent chemist, died at his home in New York City, May 24. He was born at Belvidere, N. J., Mar. 10, 1851, and graduated from Lafayette College in 1871, receiving a Ph.D degree there in 1874. For several years he was connected with the United States Department of Agriculture, and for six years, 1882-'88, he was Professor of chemistry at the University of Illinois. Later he was Consulting Chemist and Second Vice-President of the Royal Baking Powder Co., New York City, and Consulting Professor of chemistry at the Brooklyn Polytechnic Institute. He was a Past-President of the American Chemical Society, a Fellow of the American Association for the Advancement of Science, and a member of other societies and clubs in this country and Europe.

Henry Schlacks, former Superintendent of Machinery of the Denver & Rio Grande R.R., died in Chicago, Ill., May 16, aged 73 years. He was a native of Germany and came to this country as a young man. In 1855 he entered the service of the Illinois Central R.R. as a machinist apprentice. He served in the mechanical departments of various railways in the Central West until 1893, when he was appointed Superintendent of Machinery of the Denver & Rio Grande R.R. Mr. Schlacks leaves several prominent sons, Charles H., Vice-President of the Western Pacific Ry.; Henry J., an architect of Chicago; Joseph T., Vice-President of the McCord Manufacturing Co., of Detroit, Mich.; William J., of McCord & Co., of Chicago; Edward L., in the coal business in Nebraska, and Robert J., a manufacturers' agent in Denver, Colo.

Horace T. Herrick, M. Am. Soc. C. E., Superintendent of the Iowa division of the works of the Mississippi River Power Co., at Keokuk, Iowa, came to an untimely death through contact with electric wires of the Keokuk Electric Co., about 7 o'clock on the evening of May 26. Mr. Herrick was 33 years of age, a graduate of Purdue University and an engineer of great promise. He began work with Hugh L. Cooper, M. Am. Soc. C. E., Consulting Engineer, New York City, about eight years ago, in the drafting office, and since that time had made very rapid progress and developed rare professional and personal qualities, causing his death to be mourned by all of those who knew him. Mr. Herrick's experience involved important work on the McCall Ferry (Penn.) dam, and extensive reconnaissance work in the South and West and in Japan; for the past three years he has been employed on the works of the Mississippi River Power Co. The exact manner